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1949 Entomology Meetings in Tampa, Florida

The 1949 meetings of the American Association of Economic Entomologists and The Entomological Society of America will be held in Tampa, Florida on December 13–16. The Newell Entomological Society, The Cotton States Branch of the American Association of Economic Entomologists, The Florida Entomological Society, and The Florida Pest Control Association will meet jointly with the two National organizations.

The Tampa Terrace Hotel will serve as headquarters for the American Association of Economic Entomologists and the Cotton States Branch, while the Hillsboro Hotel will be headquarters for the Entomological Society of America and the Florida Entomological Society. Room reservations must be made by directing requests to A. K. Dickinson, Director, Convention and Tourist Bureau, Tampa Chamber of Commerce, P.O. Box 420, Tampa, Florida. Ample accommodations will be available for all who desire to attend.

A special and elaborate program of entertainment is being formulated for the ladies in attendance. Entomologists are being urged to bring their wives.

John T. Creighton
Chairman
Committee on Arrangements

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Failure of DDT to Control House Flies[1]

W. V. KING and J. B. GAHAN, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

A few reports concerning difficulties in the control of house flies with DDT residue treatments were received during the summer of 1947. In 1948 similar failures were observed in many places throughout the country and it became evident that a serious problem had developed. The difficulty was noticed chiefly in dairy barns and stables, but some of the reports also referred to unsuccessful results in community fly-control campaigns. Nearly all the reports stated that the same methods of treatment had been highly effective in previous years. The failures were attributed variously to poor quality or deterioration of the DDT used, increased resistance of the flies, an unusually favorable fly-breeding season, or to a let-up in sanitary practices.

A similar situation was found to exist in central Florida, and an intensive study of the problem was undertaken at the Orlando laboratory of the Bureau of Entomology and Plant Quarantine to determine what factors might be involved. A preliminary review of the information at present available is presented.[2]

REVIEW OF PREVIOUS WORK.—At the Orlando laboratory, beginning in 1946, house flies, *Musca domestica* L., were subjected to a sublethal dosage of DDT spray, and this treatment was repeated each generation on the progeny of the survivors. By the 14th generation the flies appeared more robust than the regular laboratory stock from which they had been taken originally, and were more resistant to DDT spray (Lindquist and Wilson 1948). In tests with the 15th to 17th generations, it was shown that these flies could tolerate about twice the dosage of DDT spray, or twice as long an exposure to DDT residues. They also showed an increased resistance of about the same degree to sprays containing chlordan, toxaphene, pyrethrum, rotenone, or isobornylthiocyanoacetate[3] (Wilson & Gahan 1948). The increased resistance to DDT appeared to be lost in about the same number of generations when a portion of the colony was reared without further exposure to spray (King 1948). In recent tests (unpublished) with the fifty-fifth generation of the sprayed colony, the resistance of the flies to DDT sprays had increased to such an extent that complete kill could not be obtained with very high dosages. On treated surfaces, as shown in a later section of this paper, the length of exposure required to cause 70 per cent mortality was more than 100 times that causing the same mortality of the regular colony.

Saccá (1947) reported that house flies in two localities in the Tiber Valley were not being controlled satisfactorily by DDT residues, and that in the laboratory these flies survived from 2 to 3 hours of exposure to DDT before showing the first symptoms of poisoning. This strain was named *Musca domestica* var. *tiberina*. (As no morphologic distinctions were given, the name is probably not valid.)

Wiesmann (1947) reported that house flies in the region of Arnäs, 1000 km. north of Stockholm, Sweden, were not successfully controlled in 1946 in stalls that were sprayed with DDT for the first time during that year. Specimens from this region were reared in the laboratory in Basel, Switzerland, and compared with local flies. The average knock-down time during contact with a 10-mg. deposit of DDT in a petri dish was 93 minutes for the Arnäs flies and 23 minutes for the Basel flies.

[1] This work was conducted under funds allotted by the National Military Establishment to the Bureau of Entomology and Plant Quarantine.

[2] The investigations were carried out under the direction of the authors by I. H. Gilbert, H. G. Wilson, and R. L. Peffly, and a more detailed report of the work will be prepared by them. E. F. Knipling furnished much of the information as to the situation in different parts of the United States, and also arranged for the shipment of fly material to Orlando for comparative tests.

[3] *Thanite.*

In DDT absorption through the tarsi, the LD-50 was 2.5 to 5 gamma [1 gamma = 1 microgram (.001 mg.)] for the former and 0.025 for the latter, an indication that the Arnäs strain could endure 100 to 200 times as much DDT as the Basel strain. The Arnäs strain also showed more endurance to heat and cold and to the fumes of methyl acetate. Morphologically, the cuticle of the sole and the articular membrane of the tarsal segments of the Arnäs flies were about one third thicker than those of the Basel flies. The tarsi were strongly pigmented and the bristles definitely stiffer. According to the author, the differences were sufficient to separate the flies from the two regions as races.

Blickle *et al.* (1948) described the development of increased resistance in a laboratory colony of house flies at the New Hampshire Agricultural Experiment Station after the laboratory room and fly cages had become contaminated accidentally with benzene hexachloride. The data given show a sixfold increase in resistance of the flies to gamma isomer of benzene hexachloride sprays over a period of 18 months (28 generations), based on the dosages required to give 50 per cent mortality. Resistance to a mixture of 3 parts of beta-thiocyanoethyl esters of aliphatic acids and 1 part of beta-butoxy-beta-thiocyano diethyl ether[1] was about doubled over the same period. The resistance of the laboratory colony was about three times as great as that of flies from an uncontaminated area. The laboratory-reared flies also showed about twice as much resistance to DDT, pyrethrum, and the special mixture[1] as the normal stock.

Bettini & Barachini (1948) reported experiments in Italy in which heavy applications of DDT to the walls of stables and houses failed to control house flies. Chlordan was highly effective for 4 months at dosages of 2 gm./m.^{2}. Gamma isomer benzene hexachloride was less effective at dosages of about 3 gm./m.^{2}, but gave better results when mixed with DDT. This compound caused headaches and nausea in some of the workers.

Barber & Schmitt (1948) reported the failure of DDT residue to control house flies in a hotel at Ellenville, N. Y. Laboratory tests with the first three generations of flies reared from this source showed them to be remarkably resistant to residues of DDT and dichlorodiphenyl dichloroethane, and less so to methoxychlor, in comparison with flies from a laboratory colony at the New Jersey Agricultural Experiment Station. The authors also state that the flies showed no resistance at all to residues of toxaphene, chlordan, parathion, gamma benzene hexachloride, and tetraethyl pyrophosphate. Although some of these materials were more toxic than DDT to both stocks of flies, the conclusion that the two stocks were equally resistant does not appear warranted by the data presented, except possibly in the case of toxaphene, which gave nearly equal mortalities of the two stocks of flies. With chlordan and parathion, distinct differences were shown when the dosage and exposure period were such as to give less than 100 per cent mortality, whereas with benzene hexachloride no conclusion can be drawn, as the shortest exposure period used gave 100 per cent mortality of both stocks.

RESISTANCE OF FLIES COLLECTED FROM DIFFERENT SOURCES.—Flies were collected from several locations in the vicinity of Orlando for comparison of their susceptibility to DDT. The locations were three dairy barns where frequent spraying of the walls with wettable DDT had failed to control the flies in 1948 and three city dumps (at Apopka, Winter Garden, and Kissimmee, Fla.) which, so far as could be learned, had been treated infrequently, if at all. Knock-down records during continuous exposure to DDT-treated panels and 24-hour mortality records after short exposure periods were obtained for several lots of flies from each source. In one series in which flies from all sources were tested concurrently, the average mortalities of female flies from the three dairies ranged from 1 to 22, with a mean of 11 per cent, of those from the three dumps ranged from 12 to 49, with a mean of 32 per cent, and of those from the regular laboratory colony an average of 84 per cent. In a separate series the time required to knock down 90 per cent of the flies varied as follows: 78 and 93 minutes for two dairies; 58, 59, and 60 minutes for the three dumps; and 40 minutes for the laboratory colony. The flies from one of the dairies (Lee) consistently showed greater resistance than those from any of the other sources. Flies from the dumps were considerably more resistant than the laboratory colony, and one of these stocks

[1] *Lethane 384 Special.*

showed somewhat greater resistance than the stock from one of the dairies, although the dumps were not known to have been treated with DDT. It seems probable, therefore, that previous generations of these flies had been exposed to the insecticide in other places as a result of its widespread use.

Through the assistance of different cooperators, several stocks of flies were received from various localities in several other states, as follows: Four lots from three localities in Texas (furnished by the Kerrville laboratory of the Bureau of Entomology and Plant Quarantine); several lots from a dairy at Laton, Calif., where the flies were said to show a high degree of resistance to DDT; a stock from a laboratory colony used in experimental work at Mountain View, California (received from the Stauffer Chemical Co.); one lot from a dairy in Atlanta, Georgia (collected by S. O. Hill); and one from a dairy in Raleigh, North Carolina (collected by J. C. Connor). Material from these sources was obtained as pupae, and in most cases was reared through one or two generations to increase the supply sufficiently for testing. The specimens from Laton had been reared in the laboratory of the Stauffer Chemical Co. for two or three generations before being shipped to Orlando.

The reared flies were tested when 3 to 4 days of age. They were exposed for different lengths of time to deposits of wettable DDT applied to plywood panels at the rate of 25 mg. per square foot, and were then transferred to clean holding cages for the 24-hour mortality count. From these data the regression of probit mortality on log of exposure time was computed, and the time of exposure required to produce 70 per cent mortality was obtained as a basis for comparison of susceptibility. Material from the regular laboratory colony, the special DDT-resistant colony, and the Lee dairy at Orlando was included in the tests.

All the flies from the natural sources were much more resistant than the flies from the Orlando regular laboratory colony or those from the laboratory of the Stauffer Chemical Company. The exposure time required to obtain 70 per cent mortality (LT-70), as estimated from mortality curves, ranged from 8 to 67 minutes for those from natural sources, compared with an average of 1.8 minutes (range 1.1 to 3.9 minutes in 10 series of tests) for the Orlando stock and 1.5 minutes for the Stauffer Chemical Company stock (two series). The most resistant flies obtained were those from Texas, the LT-70 of which ranged from 54 to 67 minutes for the four stocks. Next in order were flies from the Lee dairy at Orlando, for which in seven series of tests the LT-70 ranged from 16 to 73 minutes, with an average of 38 minutes. In comparison with these figures it is of interest to note that the LT-70 of the Orlando DDT-resistant colony previously mentioned was 222 minutes (average of three series), this colony showing much greater resistance than any of the stocks from natural sources. The mortality curve for this colony proved to be much flatter than usual, so that the time ratio to that of other stocks increased as the mortality level was increased. For example, its LT-50 was 100 times that of the average for the Orlando regular colony, whereas the LT-70 was 123 times and the LT-90 was 154 times the respective levels of the regular colony.

A partial summary of the data obtained is given in table 1.

QUALITY AND EFFECTIVENESS OF DDT.—In many instances the failure of DDT to control flies was thought by the dairymen to be due to inferior quality of the insecticide obtainable this year, or to deterioriation of old stocks. A number of samples of the materials in use at different places were subjected to chemical analysis at the Orlando laboratory. Most of them proved to be of approximately standard quality. Biological tests on these samples have not been completed.

Tests were also conducted in which caged flies were exposed on the treated surfaces of nine barns, three in the Orlando area and six in Mississippi, the latter represented by boards submitted by Clay Lyle from buildings at the Agricultural Experimental Station. In comparison with a range of dosages applied to plywood panels, six of the tested surfaces appeared to have residues equivalent to 100 mg. or more per square foot. In one dairy barn at Orlando where flies were exposed at several different places, the variation in mortality showed that the treatments had been very uneven.

REPELLENCY OF DDT AND OTHER INSECTICIDES TO HOUSE FLIES.—In several dairy barns where DDT residues were

Table 1.—Comparison of mortality data obtained with house flies from various sources that were exposed to plywood panels treated with wettable DDT at the rate of 25 mg. per square foot.

Stock and Reared Generation Number	Source		24-Hour Mortality After 30-Minute Exposure (Per Cent)	LT-70 (Minutes)
5 F_1	Davidson Dairy, Ozuma, Tex.		29	62
6 F_1	" " " "		25	67
7 F_1	Blue View Dairy, Dallas, Tex.		49	63
16 F_2	Stock farm, Kerrville, Tex.		37	54
9 F_1	Dairy, Atlanta, Ga.		79	28
15 F_1	Dairy, Raleigh, N. C.		54	49
14, 17, 18, 23, 24, 26; F_2 to F_4	Dairy, Laton, Calif.	Average 6 lots	72	25
		Range	53–84	8–56
25 —	Stauffer Chemical Co. laboratory colony Mountain View, Calif.	Average 2 lots	100(49)[1]	1.5
		Range	100(40–58)	1.2–1.9
Lee FO	Dairy, Orlando, Fla.	Average 7 lots	62	38
		Range	26–98	16–73
O-Special F53–54	Orlando DDT-resistant colony	Average 3 lots	14	222
		Range	9–23	193–243
O-Regular	Orlando laboratory colony	Average 10 lots	100(55)	1.8
		Range	100(17–64)	1.1–3.9

[1] Mortality from 1-minute exposures shown in parentheses.

not giving satisfactory control, it was observed that many more flies were resting in feed troughs and on untreated floors and equipment than on the treated walls and ceilings. This unusual behavior suggested the possibility that DDT had become repellent to the flies. To obtain information on this possibility, small wooden grills were treated with different formulations and then exposed side by side with untreated grills in feed troughs where flies were numerous. With wettable DDT at heavy dosages of 0.8 and 3 gm. per square foot, the fly counts were reduced by averages of 20 and 22 per cent, an indication of a significant but not high repellency. The more usual dosage of 0.2 gm. was practically nonrepellent. A 3-gm. dosage of DDT in an emulsion showed an average repellency of 31 per cent.

A similar dosage of technical benzene hexachloride (12 per cent gamma isomer) in a wettable powder showed a repellency of 35 per cent, whereas a 25 per cent gamma material showed only 15 per cent. On the other hand, a 3-gm. dosage of chlordan in a wettable powder appeared to be somewhat attractive, the average count being 11 per cent higher than that on the untreated check. When paired directly with a 3-gm. dosage of DDT, the chlordan treatment gave counts that were 25 per cent higher. Two samples of methoxychlor had slightly higher counts (6 and 1 per cent) than the control, an indication of nonrepellency for this compound.

Relative Susceptibility of Flies to Different Insecticides.—Flies from the Lee dairy and the laboratory regular colony were compared for susceptibility to residues of DDT, chlordan, methoxychlor, and technical benzene hexachloride. In one series the Lee flies were relatively more resistant to DDT than to the other materials. The LT-70 for females exposed to DDT was 11 times that of the regular colony, compared with a ratio of only 2.6 to 1 on methoxychlor, 1 to 1 for chlordan, and 0.6 to 1 for benzene hexachloride. Chlordan was the most toxic of the four compounds to the Lee flies, but less toxic than DDT to the laboratory stock. The flies from the Lee dairy in this test were the first generation reared in the laboratory and were much below the previous average from this source in resistance to DDT.

A similar comparison was made between flies of the regular and the special DDT-resistant colonies. In this test the ratios of the LT-70 of females of the resistant colony to that of the nonresistant colony were, roughly, 30 to 1 on DDT, 7 to 1 on methoxychlor, 6 to 1 on chlordan, and 2 to 1 on benzene hexachloride. The last material was the most toxic to the resistant stock.

Fly-Control Tests with Different Insecticides.—Four buildings in which DDT wettable powders had failed to give

satisfactory control were re-treated with other materials at the rate of 200 mg. of insecticide per square foot. One dairy and one calf barn were treated with chlordan emulsion, two similar buildings with suspensions of 50 per cent wettable methoxychlor, and one dairy barn first with a DDT emulsion and later with wettable DDT. Before re-treatment the wall surfaces of the dairy barn that was to be sprayed with DDT emulsion were washed with soap and water to remove the old residue, and the walls of the calf barn to be treated with chlordan were scrubbed with stiff dry brushes. The other barns were not cleaned.

A high degree of control was obtained from both chlordan and the two methoxychlor treatments, and was maintained up to the time of the latest observations (from 7 to 11 weeks after treatment). In the barn sprayed with the DDT emulsion a substantial decrease in fly abundance was recorded on the third day after treatment, but the population increased rapidly thereafter to about three-fourths of the original numbers by the eleventh day. Spraying of the grass and ground around the building had no apparent effect on the fly population. Complete respraying of the inside walls of the barn with wettable DDT a month after the emulsion treatment resulted in a reduction of about 75 per cent for 3 weeks, after which the counts in the check barns also became reduced.

SUMMARY.—Reports have been received of the failure of DDT residues to control house flies, *Musca domestica* L., under conditions in which the treatments had formerly been highly successful. The chief factor involved appears to be an increased resistance of the flies to this insecticide, probably a result of exposure in treated buildings over a period of 1 to 4 years. Samples of flies obtained from seven localities in five states all showed a greater resistance to DDT residues than that of two laboratory colonies that had never been exposed to this compound. All samples, however, were much more susceptible than a special resistant colony that has been developed experimentally at Orlando during the past 32 months.

No evidence has been obtained that inferior quality of DDT used this year was involved, or that freshly applied residues on the walls of buildings were less toxic than formerly.

Heavy deposits of DDT (0.8 to 4 gm. per square foot) showed some repellency to flies, but the more usual dosage of 0.2 gm. was practically nonrepellent. Heavy deposits of wettable chlordan and methoxychlor were nonrepellent or even slightly attractive. Technical benzene hexachloride was somewhat more repellent and a partially refined product somewhat less repellent than DDT.

Preliminary tests indicated that the increased resistance to DDT was much greater than it was to methoxychlor, chlordan, and benzene hexachloride.

Respraying of two barns with chlordan emulsions, and two with suspensions of methoxychlor provided a high degree of control for several weeks.

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A Comparison of the Chlorinated Hydrocarbon Insecticides for Control of the Sheep Tick

H. E. Fairchild, Robert A. Hoffman, and Arthur W. Lindquist, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine* and Don C. Mote, *Department of Entomology, Oregon State College*

Field experiments to compare the effectiveness of some of the new chlorinated hydrocarbon insecticides for the control of the sheep tick, or ked, *Melophagus ovinus* (L.), were initiated in November 1947 on farm flocks of sheep near Corvallis, Ore. The experiments were continued until the time of shearing in the spring of 1948. The insecticides tested were DDT, benzene hexachloride, chlordan, chlorinated camphene, methoxychlor, and dichlorodiphenyl dichlorethane. Rotenone preparations which are highly effective for controlling sheep ticks, were used as a standard of comparison.

Matthysse (1945) conducted power-dusting experiments on feeder lambs in New York and found that a dust containing 1 part of cube root (4.8 per cent rotenone) to 10 parts of pyrophyllite with 2 per cent of No. 10 motor oil added controlled sheep ticks better than did a 5 per cent DDT dust. Cobbett & Smith (1943) reported that a dip containing 2 ounces of cube (5 per cent rotenone) per 100 gallons of water gave fair control of sheep ticks, but they advised the use of freshly prepared dips containing at least 6 ounces of either derris or cube powder (5 per cent of rotenone) per 100 gallons.

Heath (1945) found that the fleece of sheep dipped in a 0.5 per cent DDT emulsion was toxic to introduced sheep ticks for at least 36 days. Rude & Parish (1946) found that immediately after treatment there were no ticks on sheep dipped once in a soluble pine oil emulsion containing 0.2 per cent of DDT, and that there were no living ticks on the sheep for at least 75 days. Kemper *et al.* (1947) eradicated ticks from sheep in the Southwest with a pine oil-DDT treatment, but on the basis of effectiveness, safety, and cost they preferred rotenone for a single-treatment control.

Materials.—Wettable powders were used for all tests. The powders were commercial preparations containing 50 per cent of the compound, except for the chlorinated camphene powder, which contained 25 per cent, and the rotenone preparation which contained 5 per cent of rotenone. The benzene hexachloride powder contained 6 per cent of the gamma isomer. All the materials except the rotenone powder were tested at concentrations of 0.05, 0.2, and 0.5 per cent, and in one test at 0.025 per cent. The rotenone powder was tested at 4, 8, and 16 ounces per 100 gallons of water.

Methods.—Experiments were conducted with both dips and sprays. A portable sheet-iron vat 42 inches long, 28 inches high, and 22 inches deep was used for the dipping. Each sheep was lifted into the vat and completely covered with the dip. Two flocks of sheep were dipped, but not more than five sheep were given each treatment.

The sprays were applied with a small gasoline-powered sprayer producing pressures of 300 to 350 pounds per square inch. One experiment was made on each of four flocks. Not more than six sheep were given each treatment. A 3-nozzle boom fitted with No. 3 disks was used in all the experiments except one, in which a 2-nozzle boom was used. Each sheep was individually sprayed. In three of the experiments the spray nozzles were held in contact with the wool and swept rapidly back and forth over the back, sides, abdomen, and neck of the animals. In one experiment, however, the spray gun was held 6 to 10 inches from the wool. At the time the animals were treated most of them had long, heavy fleece. The amount of spray applied ranged from 2.7 to 6.7 quarts per animal for all flocks, but the range within flocks was not great.

Additional information regarding the persistence of toxic action of the various insecticides was obtained by clipping samples of wool from the sides of the treated sheep at various intervals and exposing them to house flies, *Musca domestica* L., in the laboratory. Eight samples were taken from each sheep. The wool and flies were placed in petri dishes, and knock-down of flies at 2 and 4 hours was recorded. An attempt was made to expose sheep ticks to the wool samples in the

laboratory but was not continued because of the high mortality of untreated checks after 48 hours.

EVALUATION OF RESULTS.—Since the counting of all sheep ticks on an entire animal is time-consuming, one side of the neck, from the shoulder to the base of the ear, was examined thoroughly by parting the wool as the animal was held down on its side. Frequently other parts of the animal were examined, but throughout the winter more ticks were found on the neck area than on any other. In two flocks the ticks on 20 to 30 per cent of the animals were counted before treatment, and an average figure for the flock was obtained. Counts of dead and live ticks were also made on every animal 2, 7, 14, 42, 63, 84, 110, and 186 days after treatment. The percentage reduction was calculated from the numbers of live ticks found in pre- and post-treatment examinations.

Tick populations on untreated sheep on nearby farms were found to increase gradually throughout the winter and spring.

DIPPING EXPERIMENTS.—In the dipping experiments one flock of sheep was made up of yearling Shropshire ewes and the other predominantly of Southdowns. The average weight of the sheep was approximately 100 pounds. Pre-treatment counts of sheep ticks averaged 7 and 8 per animal. Although not more than 5 sheep were involved in each test, the results showed the relative effectiveness of the different compounds. At the 0.05 per cent concentration DDT, the methoxy analog of DDT, and TDE gave 97, 96, and 91 per cent reduction of ticks 42 days after treatment. The other materials, including rotenone powder at 16 ounces per 100 gallons, gave 100 per cent reduction. At the higher concentrations all the materials were completely effective during the entire period of observation, which was 110 days.

After the regular counts were made on the forty-second day, 10 to 20 live ticks collected from untreated sheep were placed on each animal treated with the 0.05 per cent concentration of insecticide. This procedure was repeated on the sixty-third, eighty-fourth, and one hundred tenth days, until a total of 70 ticks had been introduced, to determine whether reinfestation could occur. Attempts to establish a thriving colony of sheep ticks by this method failed even though most of the wool had lost its toxicity. However, some of the ticks on each animal survived. On the one hundred tenth day after treatment reductions from the original infestation were as follows: Methoxychlor 97, toxaphene 94, benzene hexachloride 98, DDT 70, dichlorodiphenyl dichloroethane 89, chlordan 84, and rotenone powder (4 ounces per 100 gallons) 91 per cent. On one flock that was examined 186 days after treatment, no live ticks could be found.

House flies were exposed at intervals to samples of wool taken from treated sheep during the first 2 months after treatment; all samples from sheep dipped in the 0.05 per cent concentration of insecticide killed all flies in 24 hours. Wool from animals dipped in rotenone powder gave 90 to 100 per cent kill. The wool treated with benzene hexachloride and chlordan gave the best results, showing 60 to 70 per cent knock-down after 2 hours' exposure. The rotenone treated wool killed house flies after several weeks, and it is probable that the animals had acquired a toxic residue by rubbing against the animals treated with the chlorinated hydrocarbons.

Samples of wool taken after the eighty-fourth and one hundred tenth days showed that benzene hexachloride, chlordan, and dichlorodiphenyl dichloroethane caused 100 per cent mortality of flies upon 24 hours' exposure. Wool from the sheep treated with the methoxy analog of DDT, toxaphene, and DDT gave approximately 80 per cent mortality. Rotenone caused 60 per cent kill.

SPRAY EXPERIMENTS.—*Experiment 1.*—A flock of Suffolk buck sheep in heavy fleece were sprayed with the three concentrations of each material. The average weight of the sheep was approximately 150 pounds. Three sheep were treated with each concentration. A 2-nozzle boom was used, and each animal was sprayed more thoroughly than it would be under practical farm conditions. The average amount applied per animal was 6.7 quarts. Pretreatment counts on the neck area averaged 21 ticks per animal.

The results of this experiment are given in table 1. After 42 days 0.05 per cent of the methoxychlor, benzene hexachloride, and chlordan killed all the ticks, and the rotenone mixture at 4 ounces per 100 gallons gave 86 per cent reduction. The reductions with the other chlorinated com-

Table 1.—Per cent reduction of sheep ticks on Suffolk buck sheep sprayed with different chlorinated hydrocarbon insecticides. Average dosage, 6.7 quarts of spray per animal.

Insecticide	Concentration (Per Cent)	Days After Treatment							
		2	7	14	21	42[1]	63[1]	84[1]	110
Methoxychlor	0.05	81	81	85	96	100	100	100	100
	.2	87	98	95	97	98	98	98	98
	.5	87	98	94	98	100	94	98	97
Toxaphene	.05	89	87	100	95	97	100	95	95
	.2	97	100	100	100	100	100	100	100
	.5	100	100	100	100	100	100	100	100
Benzene hexachloride (6 per cent gamma)	.05	100	100	100	100	100	100	100	100
	.2	100	100	100	100	100	100	100	100
	.5	90	98	100	100	100	100	100	100
DDT	.05	61	73	73	78	59	76	86	—[2]
	.2	60	81	82	87	75	76	88	—[2]
	.5	92	100	95	92	97	100	94	—[2]
Dichlorodiphenyl dichloroethane	.05	46	74	76	59	64	79	83	—[2]
	.2	92	97	98	98	95	94	97	—[2]
	.5	59	89	98	97	95	94	91	93
Chordan	.05	93	100	98	98	100	100	100	100
	.2	89	100	100	100	100	100	100	100
	.5	98	100	100	100	100	100	100	100
	Ounces per 100 gal.								
Rotenone preparation containing 5 per cent rotenone	4	81	77	86	90	86	100	100	100
	8	72	90	95	93	98	91	100	97
	16	100	100	100	100	100	100	100	100

[1] 10 to 20 ticks introduced on each sheep treated with the 0.05 per cent concentration.
[2] Sheep sold.

pounds at this concentration ranged from 59 to 97 per cent. DDT, dichlorodiphenyl dichloroethane and methoxychlor did not give complete control at any concentration. However, the methoxychlor appeared to be somewhat more effective than either of the others. Benzene hexachloride, chlordan, and toxaphene at 0.2 and 0.5 per cent showed complete control throughout the 110-day observation period.

As in the dipping tests, sheep ticks were placed on animals treated with the 0.05 per cent concentration. No living ticks were found on the animals treated with chlordan, benzene hexachloride, or chlorinated camphene, when they were examined 63 days after treatment, or on the animals treated with the first two materials after 84 and 110 days.

Wool samples collected from sheep sprayed with 0.05 per cent of the insecticides killed all the flies exposed to them during the first 2 months. The samples treated with benzene hexachloride were still 100 per cent effective after 84 and 110 days. Chlorinated camphene, dichlorodiphenyl dichloroethane and DDT showed mortalities of 87, 89, and 84 per cent, respectively, at 110 days after treatment, whereas rotenone showed 70 per cent mortality.

Table 2.—Per cent reduction of sheep ticks on Shropshire ewes sprayed with 0.2 per cent suspensions of different chlorinated hydrocarbon insecticides (Experiment 3).

Insecticide	Days After Treatment								
	2	7	14	28	42	63	84	110	186
Methoxychlor	53	81	90	92	84	97	91	83	88
Toxaphene	50	91	97	100	94	97	100	87	100
Benzene hexachloride	89	94	100	95	97	86	97	83	90
DDT	53	67	67	78	47	39	58	8	80
Dichlorodiphenyl dichloroethane	42	64	50	67	47	22	45	23	94
Chlordan	78	94	100	97	100	100	97	97	90
4 oz. of 5 per cent rotenone to 100 gallons water	54	75	83	75	88	72	34	39	100

Experiment 2.—A flock of Shropshire ewes in heavy fleece was sprayed with the various insecticides at three concentrations. Each sheep weighed approximately 125 pounds. A 3-nozzle boom was held 6 to 10 inches from the wool, and about 4 quarts was sprayed on each animal. Nearly all the insecticides gave erratic and poor reduction of ticks. When fleece is long and dense, as it is on Shropshire sheep, the spray nozzles should be held in contact with the wool or a much higher pressure must be used to obtain good results.

Samples of wool that were exposed to house flies showed erratic results, although most of the chemicals caused 95 to 100 per cent mortality of flies during the first 2 months of the test.

Experiment 3.—A flock of Shropshire ewes in heavy fleece was sprayed with 0.2 per cent of the chlorinated hydrocarbon insecticides. Each sheep weighed approximately 125 pounds. A 3-nozzle boom was held in contact with the wool, and 2.7 quarts of liquid was sprayed on each animal. Each material was applied to six sheep. The results, given in table 2, show that none of the treatments consistently killed all the ticks during the period of the test. Chlordan, benzene hexachloride, chlorinated camphene, and methoxychlor gave better results than DDT and dichlorodiphenyl dichloroethane. This experiment corroborates the results obtained in experiment 2, and also shows the difficulties of obtaining 100 per cent reduction of ticks on long, dense wool.

Wool samples treated with benzene hexachloride, chlordan, methoxychlor and DDT gave 100 per cent mortality of house flies at each of seven collection periods, up to and including the eighty-fourth day after treatment. Dichlorodiphenyl dichloroethane and toxaphene were slightly less effective, and the rotenone preparation gave poor results.

Experiment 4.—A mixed flock of Southdown and Hampshire sheep was sprayed with 0.025 per cent of the various insecticides at the rate of 3.2 quarts per animal. Six sheep were thoroughly sprayed, the nozzles being held in contact with the wool. The experiment was terminated 21 days after treatment, because several of the sheep had been sold. Benzene hexachloride, chlordan, and rotenone gave the best results, causing 84, 73, and 73 per cent reductions of ticks 21 days after treatment. DDT and dichlorodiphenyl dichloroethane again were less effective.

EFFECTS OF CLIMATOLOGICAL CONDITIONS.—The effects of climatological conditions on these experiments were also observed. On days when the air temperature reached about 70° F., sheep ticks migrated over the surface of the wool. Where the spray does not penetrate to the skin, it is possible that ticks survive for long periods or until the weather stimulates a migration on the wool surface. The mean and the highest temperatures during the test period were as follows:

Month	*Mean*	*Highest*
December	42.6° F.	60° F.
January	40.3	57
February	41.3	63
March	44.7	68
April	47.2	70
May	56.2	85

The total rainfall, which perhaps influenced the spray treatments, was 26.01 inches.

CONCLUSION.—It appears that sprays on sheep in heavy fleece are not always completely satisfactory; at least some sprays were not 100 per cent effective under the conditions of these tests, which were made with a sprayer developing a pressure of 300 to 350 pounds per square inch.

Benzene hexachloride, chlordan, and chlorinated camphene appeared to be the most effective insecticides. Rotenone gave good results, and because of the small amount needed it is by far the lowest priced treatment. A mixture of 8 ounces of derris or cube powder containing 5 per cent of rotenone is from one-fifth to one-tenth as expensive as some of the chlorinated hydrocarbons.

SUMMARY.—The comparative effectiveness of DDT, methoxychlor, benzene hexachloride, dichlorodiphenyl dichloroethane, toxaphene, chlordan, and rotenone as dips and sprays fro the control of the sheep tick, *Melophagus ovinus* (L.), was studied on farm flocks of sheep near Corvallis, Ore. In all cases wettable-powder preparations were used.

Dipping tests showed that 0.2 and 0.5 per cent concentrations of all the chlorinated hydrocarbons caused complete to nearly complete control of sheep ticks during the entire 110-day period of the test. At 0.05 per cent the results were not as satisfactory, but the introduction of

ticks on the sheep probably accounted for the less effective results. DDT and dichlorodiphenyl dichloroethane were consistently less effective than the other insecticides at this concentration. The rotenone preparation at 8 and 16 ounces to 100 gallons of water also gave excellent results. Wool samples collected from the treated sheep and exposed to house flies showed a high degree of toxicity for all chemicals at the 0.05 per cent concentration.

A spray test on Suffolk buck sheep showed that DDT and dichlorodiphenyl dichloroethane gave poor results when applied at the rate of 6.7 quarts of spray per animal and at concentrations of 0.05, 0.2, and 0.5 per cent. In a spray test on Shropshire ewes in which about 4 quarts per animal was used and the nozzle was held 6 to 10 inches from the wool, poor results were obtained with nearly all the insecticides.

When Shropshire ewes in heavy fleece were sprayed with 2.7 quarts of the chlorinated hydrocarbons at 0.2 per cent strength, none of the treatments consistently killed all the sheep ticks during the test period. Chlordan, benzene hexachloride, toxaphene, and methoxychlor gave better results than DDT and dichlorodiphenyl dichloroethane.

It was observed that sheep ticks migrated over the surface of the wool on days when the air temperature reached about 70° F.

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New Locality Records for *Allodermanyssus sanguineus* Vector of Rickettsialpox

HARRY D. PRATT,[1] JOHN E. LANE,[1] and F. C. HARMSTON, (R.),[2]
Atlanta, Ga.

Allodermanyssus sanguineus (Hirst) has assumed considerable importance to public health entomologists since the work of Huebner, Jellison & Pomerantz (1946) incriminated it as a vector of rickettsialpox from mouse to man and from mouse to mouse. It was originally described by Hirst (1914) from specimens collected on *Rattus rattus*, *Arvicanthus niloticus*, and *Acomys cahirinus* in Egypt. The first specimens reported from the United States were collected in Washington, D. C., in 1909 according to Ewing (1923, 1942). C. F. W. Muesebeck, Chief of the Division of Insect Identification, U. S. Department of Agriculture (in a footnote in Huebner *et al.*, 1946) has written "Between 1909 and 1938 only one additional record of the occurrence of this mite in the United States was brought to our notice. Since 1938, however, we have received a number of samples. These have been from Tucson, Arizona, the District of Columbia, New York, N. Y. (several samples), Philadelphia, Indianapolis and Boston. In most cases the specimens were submitted with notes indicating merely that they had been taken in houses or in apartments, but some lots were said to have been taken on man, 'causing rash'."

The work of Huebner *et al.* (1946) has shown that this mite is abundant on house mice (*Mus musculus*) in New York City in certain locations where as many as 124 cases of rickettsialpox occurred, and that the mites were infected with *rickettsiae*.

More recently, personnel of the District No. 1 office of the U. S. Public Health Service have conducted a survey of the ectoparasites on domestic rodents in the New York City area. Of 963 house mice, *Mus musculus*, examined, 92 bore *Alloder-*

[1] From the Communicable Disease Center, U. S. Public Health Service; Scientist and Entomologist, respectively.
[2] Salt Lake City, Utah, Sanitarian (R).

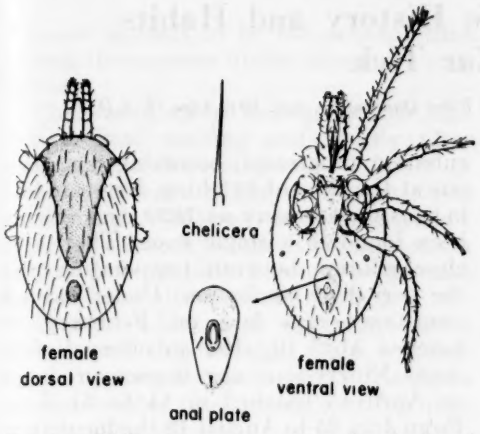

FIG. 1.—*Allodermanyssus sanguineus*, female, dorsal and ventral views, with enlarged details of chelicera and anal plate.

manyssus sanguineus. The number of *Allodermanyssus sanguineus* varied from 1 to 20 per mouse. On the other hand, no specimens of *Allodermanyssus* were found on 121 domestic rats.

During the period from September, 1945, through June, 1948, it has not been recognized in ectoparasite collections from 4070 domestic rats, *Rattus rattus* and *R. norvegicus*, trapped in nine southeastern states from Texas to North Carolina. These rats were all collected from areas where there had been no DDT dusting of rat runs. While there is a possibility that specimens of *Allodermanyssus* may have been misidentified as the similar and common tropical rat mite, *Liponyssus bacoti*, in some of these collections, a large number of the check catches have been determined most carefully. It would therefore appear that *A. sanguineus* is not a common ectoparasite of domestic rats in eastern United States although it was originally described from domestic rats in Egypt and later in this paper will be recorded from *Rattus norvegicus* in Utah.

In working over two collections of rodent ectoparasites recently the following new state records for the United States have been discovered:

Illinois: Champaign, November 8, 1934, C. O. Mohr and Dwight Powell. Host: *Mus musculus*. Three females in collection of Communicable Disease Center, Atlanta, Ga. and Illinois State Natural History Survey, Urbana, Ill.

Utah: Salt Lake City, September 21, 1948, F. C. Harmston and Roy J. Myklebust. Basement of Constitution Building, 40 South Main Street. Host: *Rattus norvegicus*. Six rats had from one to four specimens each. Twelve females in collection of Communicable Disease Center, Illinois State Natural History Survey, and U. S. National Museum.

Salt Lake City, November 6, 1948, F. C. Harmston, Roy Myklebust, and D. R. Maddock. Basement of Constitution Building. Host: *Rattus norvegicus*. Two female *Allodermanyssus sanguineus* from a pool of four rats. Material in Communicable Disease Center collection.

Females of *Dermanyssus* and *Allodermanyssus* have the chelicerae drawn out to a single point while the other parasitic mites in the families Laelaptidae and Dermanyssidae have more or less scissor shear-like chelicerae with two chelae. Females of *Dermanyssus* have a single, large, dorsal plate, while those of *Allodermanyssus sanguineus* are easily recognized by the small, posterior dorsal plate in addition to the larger, anterior, dorsal plate. (Fig. 1).[1]

[1] We wish to acknowledge the assistance of Dr. C. O. Mohr in preparing the original illustrations of these mites which are based on specimens collected at Queens, New York City in 1946 by William L. Jellison and Charles Pomerantz.

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Recent Studies on Life History and Habits of the Ear Tick

HENRY E. PARISH,[1] *Bureau of Entomology and Plant Quarantine, Agr. Res. Adm., U.S.D.A*

In the semi-arid portion of the Southwest, which is one of the principal livestock-producing sections of the United States, the ear tick, *Otobius megnini* (Dugès), is a serious pest of cattle as well as of other animals. This parasite is so well established in this section that livestock owners pay little attention to it until the population reaches serious proportions. It develops in the ear and can be detected only upon close examination. As many as 100 have been removed from the ears of a single cow.

The life history of this parasite, then known as the spinose ear tick, *Ornithodoros megnini* (Dugès), was described by Hooker *et al.* (1912). More recent studies conducted to secure additional information regarding the habits of this tick are reported herein.

One of the most serious consequences to livestock is a predisposition to screw-worm attack. Infested animals scratch their ears with their hoofs, causing laceration of the ear and occasional crushing of nymphs engorged with blood, and thus create a condition which invites oviposition by screw-worm flies. In the course of screw-worm investigations in Menard and Kimble Counties, Texas, during the years 1936–1940, it was found that ear ticks were responsible for 4 per cent of the 5812 cases recorded.

In addition to the loss of livestock from screw-worm attack as the result of ear-tick infestations, there is a further loss due to reduction in body weight, wool, mohair, milk, and, in work animals, efficiency. Valuable dogs used in handling livestock have also died from screw-worm infestation in wounds caused by ear ticks. Animals, especially sheep and cattle, which are grossly infested with ear ticks, lack thrift, which doubtless affects breeding and results in a reduced lamb and calf crop. However, this tick is not known to transmit any disease to either man or animals.

EGG STAGE.—The eggs are elliptical in shape, and are honey yellow when first deposited, but soon turn to a dark brown. Whitish spots appear on the eggs as incubation progresses, becoming conspicuous at the time of hatching. Eggs are laid in masses, as many as 1939 eggs having been found in a single mass. There is a close relation between temperature and the period of incubation. Under natural conditions eggs laid on February 20 hatched April 10, after an interval of 50 days. Ninety-four egg masses produced on April 15 hatched in 14 to 31 days. From July 25 to August 18 the incubation period ranged from 7 to 12 days, the average being 10.4 days.

PARASITIC STAGES.—Soon after hatching the larvae become very active. When in confinement they migrate to the top of the container, cluster, and often fall to the bottom, only to repeat the procedure. Debris under salt troughs has been noted to be literally crawling with larval-stage ticks, and they will readily crawl up on man or animals when given an opportunity. In fact they will crawl upward on any available object, to await hosts on which to attach.

In about 5 to 10 days after reaching the external ear of the host, the larvae become engorged, and while in this stage they become pear-shaped and so remain for 1 to 5 weeks. Molting takes place in the ear, resulting in the spiny, or nymphal, stage. Soon after molting, engorgement of the nymphs begins, and lasts for 2 or more months. When completely engorged, nymphs detach, fall to the ground, and rapidly seek cover under some convenient object, for the final molting.

Under laboratory conditions fully engorged nymphs, before molting, cease moving of their own accord and show very little response when disturbed. They change from a yellowish brown to a dark brown, and in the early stage of the process take on a glazed appearance. As molting progresses, the outer skin slits along the sides and begins to wrinkle over the abdomen. After the emergence of the adult a light yellow, purse-shaped cast skin is left. The time required for molting ranges from 4 to 24 hours, although 6 to

[1] The writer expresses his appreciation to C. S. Rude for valuable assistance and suggestions in conducting these studies.

8 hours appears to be the average time during the summer under laboratory conditions.

The mortality of the ear tick is high during final molting and shortly after emergence of the adult.

ADULT STAGE.—The newly emerged adult is slate-colored with light yellow legs, but a few days later it becomes much darker and the skin becomes tough and hard. The adults consume no food.

MATING.—Mating is necessary before females will deposit eggs. Only one successful mating is required for a female to produce viable eggs throughout her productive life.

To determine whether females would produce eggs before mating, 10 fully engorged nymphs were confined individually in test tubes partly filled with moist sand where they were allowed to molt. The resulting females were maintained in the same tubes without males for 78 days, which is more than ample time for egg production. At the end of this period males were placed in 8 of the tubes but not in the others. Egg deposition began in 5 to 16 days in all tubes where males had been introduced, whereas in the tubes without males no eggs were deposited.

When mated females were placed individually in pill boxes, the several egg masses produced by each female over an extended period resulted in apparently normal larvae without the presence of a male after the initial mating.

PRE-OVIPOSITION PERIOD.—During April and May 1942 observations were made on 64 females maintained under laboratory conditions to determine the length of the period between molting into the adult stage and oviposition. The maximum time was 32 days and the minimum 6 days, the average being 12.5 days.

Climatic conditions no doubt greatly influence the time required in each developmental stage of this tick.

OVIPOSITION.—From June through September 1942 observations were made on 20 newly emerged females to determine the number of eggs they produced and the period over which egg laying took place. After being mated each tick was placed in a pill box and kept under laboratory conditions until it died. At regular intervals the eggs in the egg masses were counted. The greatest number of eggs recorded from any one tick was 1939, the smallest number was 794, and the average 1444. The maximum number of egg masses produced by an individual tick was 11, the minimum 2, and the average 5.8. In all but two cases the initial egg mass produced contained more eggs than any that were deposited thereafter by the same tick. Generally the last few clusters contained few eggs.

To what extent ear ticks produce eggs during the late fall, winter, and early spring was determined by a test begun on October 24, 1942, and continued for 25 weeks. Fifteen adult ticks were placed in each of 25 2-ounce metal salve boxes partly filled with sterilized debris taken from under salt troughs. These boxes were placed under a salt trough especially constructed to simulate natural conditions. Only two small egg masses were produced during November and December, from each of which one larva hatched, and only four small egg masses during February, which did not hatch until April 10. No egg masses were produced during January. The warm weather in February may stimulate a limited amount of oviposition, but incubation does not generally occur until March. Under natural conditions only a limited number of eggs are produced from November through February but full egg production is in effect for the remainder of the year. This information is of considerable value in control work on this extremely important animal parasite.

Loss in body weight through egg production from November 6, 1942, to April 23, 1943, was demonstrated to be more rapid in 100 females maintained in the laboratory than in the same number kept in a screened house during this cold period. Both lots of ticks were weighed once a week.

LONGEVITY.—Several thousand newly hatched, unfed larvae were placed in a glass jar with a screw cap and kept in the laboratory to determine how long they would survive without food. Few died during the first 20 days; the mortality was greatest between the thirtieth and fortieth days. By the sixty-sixth day all the larvae were dead.

To determine how long adult ticks live, 750 specimens were placed in a glass jar partly filled with moist sand, and 761 were placed in a jar containing debris from under a salt trough. Each jar was covered

with cloth held in place by a rubber band. In the jar containing sand one specimen survived 375 days, while in the jar containing salt-trough debris one adult lived 472 days.

EFFECTS OF SUBMERGENCE IN WATER.—All mobile stages of the ear tick are remarkably resistant to submergence. This species of tick may therefore be disseminated by water as well as by the movement of infested livestock.

When submerged, engorged nymphs and adults cease activity immediately, whereas the larvae continue to move for several hours. A series of tests was conducted to determine how long the various stages could survive submergence. Adults showed some mortality within 4 hours and 100 per cent in 49 hours, engorged nymphs some mortality in 16 hours and 100 per cent in 97 hours, and newly hatched larvae some mortality in 53 hours and 100 per cent in 163 hours.

LOCOMOTION.—Some observations were made on the distance that engorged nymphs and adults travel. In the laboratory, where no suitable cover was available, they crawled several feet, but when any cover could be found they traveled a much shorter distance. Of 197 fully engorged nymphs released on the ground at a central point, 67 per cent were recovered 3 days later within 4 inches of the point of liberation. The farthest point from which recovery was made was 18 inches.

In tests in which 400 engorged nymphs were allowed to choose either pure salt or dirt in which to hibernate, about half of them chose salt. This tick is therefore not attracted to or repelled by salt.

ANIMAL IMMUNITY.—It has been observed that some animals resist the attack of the ear tick, as repeated implantations of larvae have failed to produce infestation in some sheep. One cow was artificially infested with about 1000 larval ticks at weekly intervals during two tick seasons. The cow appeared to be immune to the parasite as no larval ticks became established during this period of observation.

HOSTS.—Ticks in the nymphal stage have been collected from the following hosts in the vicinity of Menard, Texas: Cattle, sheep, goats, dogs, deer, and man. Other writers have recorded this tick as infesting a number of other animals.

EFFECT OF SOIL TEMPERATURE ON ENGORGED NYMPHS.—A series of tests was conducted to determine the fate of engorged nymphs dropping from the host to the soil where no protection was offered during hot, dry periods. Five specimens were exposed on bare ground for a known period, during which time the temperature was recorded with an automatic recording soil thermometer. The ticks were then placed in pill boxes on moist sand and observed. At 120° F. no mortality was recorded after 2 minutes and 60 per cent mortality after 5 minutes; at 128° the mortality was 60 per cent after 1 minute, 80 per cent after 2 minutes, and 100 per cent after 3 minutes. These soil temperatures are not uncommon in many sections of the Southwest and may account for the destruction of many ticks dropped from hosts in locations where protection is not readily available. Ticks dropped onto hot soil move rapidly, generally in a circle, or attempt to dig into the soil. If they find no protection from the heat in a few minutes, their abdomens become distended and they soon die.

PARASITES AND PREDATORS.—During the course of these investigations approximately 45,000 engorged nymphs and adults were collected and observed almost daily for a year to determine whether any were parasitized. No parasites were recovered from this large number of ticks.

Small black ants, *Monomorium minimum* (Buckley), were observed feeding on newly emerged adults in the laboratory. In the field large red ants, *Pogonomyrmex barbatus* var. *molefaciens* (Buckley), were observed attacking adults as well as fully engorged nymphs.

COLLECTIONS OF NON-PARASITIC STAGES.—Specimens for biological study were sought in debris in and around places frequently visited by animals. Top soil and debris were examined to determine the population in various situations. For each sample enough material was taken to fill a No. 2 wash tub. All samples were washed through a screen before being examined for ticks. Of 26 samples from 10 different types of locations only five specimens were found, three from goat-shed debris and two from bed-ground samples. A sample of debris from under a salt trough, however, showed a heavy tick population.

In view of this finding all efforts were

devoted to the examination of the debris under salt troughs. The debris under the first two troughs examined yielded 902 engorged nymphs and 1062 engorged adults. This discovery not only supplied much needed material for biological and experimental work, but opened a new approach for the reduction of the ear tick.

SALT TROUGH POPULATION STUDIES.—Studies of tick populations under salt troughs on two ranches, one in Menard and the other in Kimble County, revealed that the numbers of ear ticks present varied in proportion to the animal population maintained in the pastures. Studies were also conducted to determine the relation between salt-trough location and tick population. Ticks were found under all the 37 troughs examined. Fewer ticks were found under troughs standing in water during rainy spells. The population under the troughs was higher in pastures stocked with cattle and sheep than in those stocked only with goats. The largest numbers of ticks were found under troughs located on rocky slopes, where water never stands, in pastures where the cattle population was continuously high. The largest number of ticks found under one trough was 2095.

On one ranch which maintains about 5000 head of all classes of livestock, 9180 ticks were collected from under 11 salt troughs. On the assumption that the numbers of males and females collected in nature are about equal, this collection contained 4590 females. Females deposited an average of 1444 eggs each. Therefore, this one collection removed females capable of producing 6,627,960 progeny, or an average of 1325 per animal on the ranch. Experimental work done by C. S. Rude and C. L. Smith of the Bureau of Entomology and Plant Quarantine (unpublished data) with artificial tick implantation in cattle reveals that approximately 5 per cent of the larvae implanted establish and become nymphs. On this basis, the females removed were capable of producing approximately 66 nymphs per animal on the ranch.

Ticks were found under salt troughs in each month of the year, but the peak of abundance occurred between April 25 and July 25. The number was rather uniform from August 25 to November 25, and was much smaller from December 24 to March 25. Although the total number of nymphs was smaller, the number of engorged nymphs was much greater during the last period, an indication that the transformation period from nymphs to adults is lengthened by cold weather.

SUMMARY.—The ear tick, *Otobius megnini* (Dugès), is a serious pest of cattle in the Southwest, because it weakens and predisposes animals to screw-worm infestations. It develops in the external ear of the animal. Studies of the habits of this tick were made in Menard and Kimble Counties, Texas, during 1942 and 1943.

Eggs laid in February required 50 days to hatch, while those laid from late in July until about the middle of August hatched in about 10.4 days.

Larvae entered the external ear and became engorged in 5 to 10 days, then molted into nymphs 1 to 5 weeks later. Nymphs engorged for 2 or more months, then dropped to the ground and sought cover before the final molting.

Adult ticks did not feed. Only a single mating was required to produce several viable egg masses. During April and May the preoviposition period averaged 12.5 days in the laboratory. From June through September, on an average 1444 eggs, in 5.8 egg masses were deposited per individual.

When larvae were held without food, most of them died in 30 to 40 days, and all were dead after 66 days. One adult lived 472 days.

All mobile stages of the ear tick were remarkably resistant to submergence, an indication that the species may be disseminated by water. Engorged nymphs and adults crawled only a few inches if cover was available. Mortality was high after a few minutes' exposure on soil at temperatures from 120° to 128° F.

Heavy tick populations were discovered in the debris under salt troughs in pastures. This discovery opened a new approach to the control of the ear tick.

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The Residual Property of DDT as Influenced by Temperature and Moisture

A. F. Burgess[1] and Harvey L. Sweetman, *University of Massachusetts*

The long-lasting residual property of DDT is one of its outstanding qualities. It is recognized that the period of effectiveness of a given concentration varies considerably under different environmental conditions (Sweetman 1945). DDT is reported to be relatively stable at the usual temperature and moisture conditions at which it is used insecticidally. Since the residual effectiveness is much greater when it is used against household pests where the physical environment is more uniform than against field pests it suggests that temperature, moisture and light may be important factors of the physical environment that influence residual effectiveness. Harman (1945) suggested that weathering or possibly a break down into a less toxic form accounts for the loss of residual toxicity in the field. Fleck (1944) has attributed loss of residual toxicity to evaporation. Gahan *et al.* (1945) have reported that DDT is affected deleteriously by sunlight. Lindquist *et al.* (1946) showed that DDT when exposed to either ultraviolet light or sunlight was appreciably reduced in effectiveness, especially in liquid deposits. Gunther *et al.* (1946) reported that DDT deposits under field conditions showed a steady and gradual decline in the quantity of deposit over an 86-day period. Heavy rains in the latter part of the period had no demonstrable effects upon the magnitude of the deposits. They did not distinguish between removal of DDT deposits by weathering and by chemical decomposition. Gunther (1947) commented on the thermal decomposition of DDT in admixture with benzene hexachloride, presumably because of traces of iron in the benzene hexachloride preparations. Bushland *et al.* (1945) found that DDT stored at 60° C. (140° F.) for 10 months lost about half of its toxicity but did not lose its effectiveness after several months' exposure to the open air or when exposed at 60° C. for 2 months. Jones *et al.* (1945) reported that arm and leg garments treated with DDT showed no difference in effectiveness after storage for one year.

The results reported herein deal with the influence of temperature and moisture on residual effectiveness of DDT. The experiments were conducted in a basement laboratory so that direct sunlight was not a factor in the tests. Indirect sunlight and artificial light were relatively low in intensity where the experiments were conducted. The housefly, *Musca domestica* L., was used as the test organism. The influence of temperature and moisture on the residual effectiveness of DDT, using two species of Thysanura, the silverfish, *Lepisma saccharina* L., and the firebrat, *Thermobia domestica* Pack,. and the American cockroach, *Periplaneta americana* L., has been reported (Sweetman 1945).

Pieces of wire screen, galvanized and black enameled, were cut in 3 by 3 inch squares. The galvanized screen had 14 meshes per inch and the black screen 12 meshes per inch. These screens were dipped in 5 per cent DDT in deodorized kerosene, then placed on racks in a flat position to dry. This treatment left a somewhat irregular deposit of DDT crystals on the screens. The treated screens were exposed in the laboratory and in temperature and moisture chambers ranging from 23° to 37° C. High and low moisture conditions were provided except at 34° and 37°, which had high moisture only. The relative humidity varied from 60 to 75 per cent in the moist chambers and from 25 to 40 per cent in the dry environments. The influence of temperature and moisture on the residual toxicity was tested from time to time over a period of 3 years. Three-day old house flies were placed in the test cages with food, dry powdered milk, and water. The latter was in a petri dish. The treated screens were placed on the petri dishes leaving narrow openings along the screen edges so that the flies seeking water would crawl on the screens. This resulted in repeated exposure of the flies to the screens. Twenty-five flies per test were used during the first 5 months while a variable number, usually in excess of 25, were used in later tests.

The screens were weighed at intervals

[1] Retired. Formerly with the Bureau of Entomology and Plant Quarantine, U.S.D.A.

to get some idea of the amount of DDT deposited and of changes in weight. A series of data started in April, 1945 are given in table 1. Screens weighed before, and 3 days after, treatment showed an increase in weight of 5 to 6 mg. This presumably was DDT as the deodorized kerosene appeared to dissipate from the screens rapidly. However, the weight continued to increase for several weeks presumably because of the accumulation of dust or other debris adhering to the screens. The weight of the treated screens remained relatively stable after the initial increase. The weight changes of a series of untreated screens was determined for comparison at the same time (Table 2).

A series of 40 screens was treated in April, 1945 and a majority kept on test for 3 years. Each screen was tested once during the first 5 months, again approximately at 18 and 36 months after treatment, making three exposures to flies during the experiment. Thus well over a hundred flies were exposed to each individual screen while on test, which perhaps removed an appreciable portion of DDT. However, a microscopic examination revealed crystals that appeared to be DDT on the more toxic screens at the close of the experiment.

The data from these tests are given in table 3. The screens in all environments remained highly effective throughout the first tests, one to five months after treatment. The mortality was 100 per cent in all cages, usually in less than 48 hours, but one test required 67 hours.

Appreciable changes in toxicity were evident in 17 to 18 months after treatment (Table 3). At 37° the average mortality of exposed flies was reduced to 53 per cent at 72 hours, but one screen showed no toxicity during a 9-day test. The screens held at 34° were not tested at the 18-month interval. Most of the screens at 32° and 23° remained highly effective, although four produced mortalities well below 100 per cent, three showing appreciable reduction in toxicity.

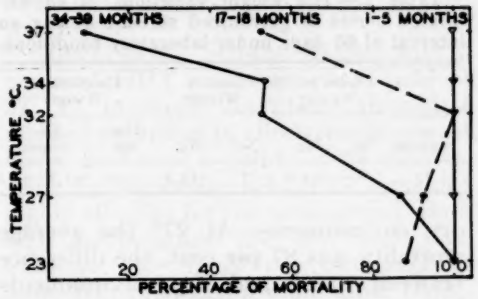

FIG. 1.—The average mortality of house flies after exposure for 72 hours to DDT treated screens which had been held in various temperature and moisture conditions for 1 to 39 months.

The longer exposure period, 34 to 39 months, produced marked reduction in the mortality rates of exposed flies in comparison with the earlier tests. The screens at 37° were practically non-toxic, the average mortality being reduced to 9 per cent, since the single screen remaining toxic produced 47 per cent mortality among the flies during the first 72 hours' exposure. No further mortality in this cage occurred during a 10-day test. The mortality declined to 53 per cent at 34° and 32°, but at the latter temperature nearly all of the deaths occurred in the

Table 1.—The increase in weight of 3″×3″ screens following treatment with DDT solutions and the subsequent changes in weight.

No. of Samples	Initial Weighing	Average Changes in Weight (Mg.) Between Weighings: Days After Treatment											
		3	11–13	29	45	63–69	91–105	124–136	154	181	194–199	269	335
						Galvanized Screen							
1	B	+5.9	—	—	—	—	−3.9	+3.0	—	—	−1.0	0.0	−0.8
3	A-3	—	+13.8	—	—	+2.3	—	−0.6	—	—	−0.67	—	—
2	A-3	—	+14.0	—	—	—	—	—	—	—	—	—	—
6	B	—	—	+17.0	− 1.03	—	—	—	—	−1.77	—	—	—
8	B	—	—	—	+16.4	0.0	—	—	—	−1.6	—	—	—
8	B	—	—	—	+16.7	—	−0.44	—	—	−1.64	—	—	—
8	B	—	—	—	+18.7	—	—	−0.79	—	−0.06	—	—	—
8	B	—	—	—	+16.8	—	—	—	−0.78	−1.29	—	—	—
6	A-11	—	—	—	—	−1.6	−0.82	—	—	—	−1.4	—	—
						Black Enameled Screen							
1	B	+5.0	—	—	—	—	−2.0	+1.0	—	—	+1.0	−1.0	0.0
2	A-3	—	+18.0	—	—	−0.1	—	−0.4	—	—	−1.5	—	—
3	A-3	—	+16.3	—	—	—	—	—	—	—	—	—	—
6	A-11	—	—	—	—	−0.63	−0.02	—	—	—	−3.4	—	—

B = before treatment, A-3 = three days after treatment.

Table 2.—The weight variations of an untreated series of galvanized screens during an interval of 60 days under laboratory conditions.

Number of Screens	Gain in Weight		Loss in Weight		Changes in Weight	
	No.	Mg.	No.	Mg.	Average	Extremes
18	8	+4.9	7	−13.3	1.01	+1.3 −5.5

dry environments. At 27° the average mortality was 87 per cent, the difference between moist and dry environments being much reduced. The screens exposed at 23° were separated in moist and dry conditions during the first 18 months, but thereafter were held under general laboratory conditions. These results are shown graphically in figure 1. The mortality curve for the first 5 months is a straight line at 100 per cent. The 18-month curve ranges from 88 to 100 per cent from 23° to 32° at 72 hours. However, the mortality approximated 100 per cent

Table 3.—The effectiveness of DDT treated screens against house flies after exposure in various temperature and moisture conditions.

Months After Treatment	Average Percentage of Mortality		
	Hours		
	24	48	72
	37°C. Moist		
1–5	86.4	100	100
17	21.8	44.4	52.6
39	3.6	—	9.4
	34°C. Moist		
1–5	91.2	100	100
39	32.6	—	53.4
	32°C. Moist		
1–5	87.2	100	100
17	89.6	100	100
34–35	4.4	11	13.8
	32°C. Dry		
1–5	82.4	90.4	100
17–18	90.4	100	100
38–39	—	82	91.4
	27°C. Moist		
1–5	90.4	100	100
18	66.4	78.6	94
39	—	96.2	96.2
	27°C. Dry		
1–5	97.6	100	100
18	68.2	83.6	91.2
36–38	54.2	63.7	77.6
	23°C. Moist		
1–5	77.6	100	100
18	52	79.2	87.2
38	79	—	100
	23°C. Dry		
1–5	88	100	100
18	64.3	77.6	89
38	71	100	100

Table 4.—A comparison of the effectiveness of treated screens after 34 to 39 months with the gain in weight following treatment.

Temperature °C.	Increased Weight After Treatment-Mg.		Percentage Mortality at 72 Hours
	45 Days	181 Days	After 34–39 Months
37	17.0	14.2	0
37	14.4	12.2	0
37	26.0	23.8	47
37	20.0	14.0	0
34	16.5	13.5	48
34	21.5	18.0	42
34	16.0	13.3	74
34	16.0	14.4	43
34	19.5	15.5	60
32-dry	15.0	12.0	100
32-dry	1.6	0.6	100
32-dry	15.5	12.0	100
32-dry	25.0	20.5	100
32-dry	12.0	9.0	57
32-moist	17.0	14.5	17
32-moist	15.0	12.0	0
32-moist	7.0	14.5	46
32-moist	3.0	9.5	6
27-dry	20.0	18.0	97
27-dry	22.0	20.1	100
27-dry	15.0	13.5	84
27-dry	18.0	15.5	72
27-dry	28.0	24.5	35
27-moist	22.0	21.0	84
27-moist	22.5	21.7	100
27-moist	20.0	18.5	100
27-moist	24.5	22.8	100
27-moist	16.0	13.0	100
23	8.3	8.2	100
23	18.0	18.3	100
23	11.5	11.0	100
23	14.0	12.7	100
23	21.0	19.5	100

at the end of 9 days. Five of the original screens exposed at 23° were under test for 38 months. These five produced 100 per cent mortality of flies.

The screens discussed in table 3 and figure 1 were weighed before treatment and 45 and 181 days after treatment. It was shown in table 1 that an increase in weight following treatment of the screens continued for 2 weeks or more, after which a very slight decrease in weight occurred. It appeared that at least half of the increase in weight was due to dust adhering to the screens. There is some correlation between the initial gain in weight of the screens following treatment and the

effectiveness of the screens 34 to 39 months later (Table 4). At 37° the only screen remaining toxic had the greatest increase in weight following treatment. The weights and persistence in effectiveness at 34° were rather constant. The results are more variable at 32°, but in general low increase in initial weight correlates with reduced persistence in effectiveness with the exception of one screen. It appears that an error was made in the original weighing of this screen. At lower temperatures the screens remained quite toxic with one exception. However, this screen showed the greatest increase in weight following the original treatment.

CONCLUSION.—Screens treated with 5 per cent DDT in kerosene and held at 37° C. in moist conditions showed a marked reduction in effectiveness against house flies over a period of 39 months, while similar screens held at 23° remained highly effective for the same period. Both high temperature (37° C.) and high moisture (60 to 75 per cent relative humidity) produced a more rapid reduction in toxicity of DDT than low temperature (23° C.) and low moisture (25 to 40 per cent relative humidity).

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Piperonyl Butoxide, Piperonyl Cyclonene, and Pyrethrum Applied to Selected Parts of Individual Flies

CHARLES S. WILSON,[1] *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Intelligent selection of materials to be included in new types of pyrethrum formulations requires considerable knowledge of the actions of the chemicals included in the large group loosely called "synergists." Reasonably valid inferences may be made as to the principal actions of many of these materials. Lubricating oil, for example, probably serves to retard evaporation and to maintain droplet size in sprays, and antioxidants (isopropyl cresols, pyrogallic acid, etc.) have been used with the pyrethrum in louse powders. The action of the important group of piperonyl compounds, however, is less obvious. The conspicuous effect of some of these is to inhibit recovery after knockdown by pyrethrum, and some have been reported to reduce the time required for knock-down. Hartzell (1945, 1946) observed that in house flies sprayed with piperonyl compounds there was vacuolation of the larger nerve cells of the brain and accentuation of the nodes and Krause's membrane in striated muscles. The significance of these observations is questioned by Richards & Cutkomp (1945) and by Hoskins & Craig (1946), in that an observed histological effect may be incidental to, and not the site of, critical injury to the insect. Lindquist *et al.* (1947) found sesame oil concentrate, piperonyl cyclonene, and N-isobutylundecylenamide to be effective on house flies when sprayed before but not when sprayed after pyrethrum.

[1] Now with the Federal Security Agency, Public Health Service, Alaska Health and Sanitation Activities.

Table 1.—Effect of site of application of pyrethrum on flies. Dose: 0.1 microgram of pyrethrins applied as a 0.4 per cent solution in deodorized kerosene.

Site of Application	Knock-Down	Average Time Required for Knock-Down	Recovery	Average Duration of Knock-Down	Survival	
					At 4 Hours	Overnight
	Per Cent	*Minutes*	*Per Cent*	*Hours*	*Per Cent*	*Per Cent*
Tests with *Musca domestica* (5 flies per test, 12 replications)						
Top of thorax	40	13	97	1.2 to 1.4	98	90
Thoracic spiracle	100	3	97	2.4	97	90
Mouth parts	100	1	93	2.2 to 2.6	92	67
Tests with *Calliphora vomitoria* (10 flies per test, 2 replications)						
Top of thorax	85	14	88	3.3 to 5.8	75	75
Thoracic spiracle	100	1	90	3.9	90	90
Mouth parts	100	1	90	4.4 to 4.9	90	85

Synergists are difficult to study because separation of the factors involved is likely to destroy the synergistic action. Lindquist and his associates (1947) made an important step forward when they showed that doses of some synergists could be separated in time from the accompanying doses of pyrethrum and still be effective. This separation allowed the conditioned insect to be studied, but the spray technique they used did not tell whether the surface had been conditioned by a drop of synergist that had fallen on the spot, or whether some internal structure or system had been conditioned by synergistic material that might have been absorbed from a different part of the insect. This uncertainty was eliminated in the present preliminary studies conducted at the Corvallis, Oregon, laboratory of the Bureau of Entomology and Plant Quarantine, by a procedure that allowed the time, location, and amount of each dose to be predetermined. As many doses as desired could be applied to the same or to different parts of each individual insect.

METHODS AND MATERIALS.—A method devised by J. Franklin Yeager and Sam C.

Table 2.—Effect of site of application of pyrethrum, alone and with piperonyl butoxide, on flies. Dose: pyrethrins 0.1 microgram, synergist 1.0 microgram.

Treatment and Site of Application	Average Time Required for Knock-Down[1]	Recovery	Average Duration of Knock-Down	Survival	
				At 4 Hours	Overnight
	Minutes	*Per Cent*	*Hours*	*Per Cent*	*Per Cent*
Tests with *Musca domestica* (5 flies per test, 4 replications)					
Top of thorax:					
Pyrethrum alone	7	95	1.8	95	85
Pyrethrum on thorax and synergist on abdomen	23	10	5.0 to 11.3	10	10
Pyrethrum and synergist combined	14	5	3.7	5	0
Thoracic spiracle:					
Pyrethrum alone	2	95	3.4	95	85
Pyrethrum on spiracle and syngergist on abdomen	1	5	7.5 to 17.1	5	5
Pyrethrum and syngergist combined	2	0	—	0	0
Mouth parts:					
Pyrethrum alone	1	95	3.2	90	55
Pyrethrum on mouth parts and synergist on abdomen	1	15	7.8 to 14.5	15	15
Pyrethrum and synergist combined	1	0	—	0	0
Tests with *Calliphora vomitoria* (10 flies per test, 2 replications)					
Thoracic spiracle:					
Pyrethrum alone	1	90	3.9	90	90
Synergist on one spiracle and pyrethrum one hour later on the other spiracle	1	10	7.9 to 16.5	10	10
Pyrethrum and synergist combined	1	0	—	0	0

[1] Knock-down 100 per cent, except for first treatment on top of thorax, for which it was 60 per cent.

Munson (unpublished) was used to pick up doses of suitable size and good uniformity on small loops of fine wire. The loops were calibrated by shaking the droplets of test solutions carried by them into small dishes of ethyl alcohol that had been half-saturated with kerosene to reduce the rate of solution. The diameters of the droplets suspended in the alcohol were measured under a dissecting microscope and, since the droplets left the loops cleanly, it was assumed that the calculated volumes closely approximated the volumes applied to the insects. Laboratory-reared flies, *Musca domestica* (L.) and *Calliphora vomitoria* (L.), were handled singly in glass tubes (1.5 by 6.0 cm.) stoppered at both ends with drilled corks. When a dose was being administered, the stopper at one end of the tube was replaced with a wire-screen thimble and the fly gently pressed against the screen with a cotton-covered plunger inserted into the other end of the tube. The wire loop was dipped into the test solution and, with the fly held under dissecting binoculars, the drop was deposited on the selected part of the fly. Then the loop was rinsed in acetone, the stoppers were replaced, and the tube was set up for observation. Since the method is fast, requires very little working space or equipment, and uses the minimum of materials, it appears to have possibilities for screening contact insecticides, knock-down agents, and synergists.

Facilities were not available for maintenance of highly standardized conditions, and there was considerable variation in day-to-day response to standard doses. The tests, therefore, were arranged in sets, so that each treatment of the series being compared was administered to equal numbers of flies taken on the same day and from the same stock. Consequently, only a small number (usually five) received a particular treatment on any one day, and the sets were repeated usually four or more times to make up the total samples. The results of each set of tests are included in tables 1 to 3. Comparisons can be made within the same set, but similar comparisons of samples in different sets are of doubtful validity.

The flies were kept in their tubes without food or water throughout the tests. Natural mortality was low but may have been sufficient to affect overnight survival. It had little or no effect on survival at 4 hours. All flies that were able to crawl at the time of the morning observation were

Table 3.—Effect of site of application of pyrethrum, alone and with piperonyl cyclonene, on house flies. Dose: pyrethrins 0.1 microgram and synergist 1.0 microgram.

Treatment and Site of Application	Knock-Down	Average Time Required for Knock-Down	Recovery	Average Duration of Knock-Down	Survival	
					At 4 Hours	Overnight
	Per Cent	*Minutes*	*Per Cent*	*Hours*	*Per Cent*	*Per Cent*
	(5 flies per test, 4 replications)					
Top of thorax:						
Pyrethrum alone	10	21	100	0.8	100	100
Pyrethrum on thorax and synergist on ventral abdomen	50	66	50	1.5 to 3.6	70	50
Pyrethrum and synergist combined	25	79	20	4.3	80	55
Thoracic spiracle:						
Pyrethrum alone	100	5	95	1.5	95	90
Pyrethrum on spiracle and synergist on ventral abdomen	100	4	60	3.0 to 4.7	60	50
Pyrethrum and synergist combined	100	4	30	5.9 to 12.4	30	25
Mouth parts:						
Pyrethrum alone	100	2	85	1.3	85	60
Pyrethrum on mouth parts and synergist on ventral abdomen	100	3	75	3.8 to 5.2	75	55
Pyrethrum and synergist combined	100	2	10	4.7	10	5
	(10 flies per test, 2 replications)					
Mouth parts:						
Pyrethrum alone	100	2	90	1.9	85	60
Piperonyl on mouth parts and pyrethrum one hour later	100	1	0	—	0	0

counted as "overnight survivors." "Survivors at 4 hours" include those flies that were still down at the end of that period but were found to have recovered at any time thereafter, even though some of them died before the morning observation. Flies were considered knocked down when they were unable to crawl on the vertical wall of the tube with reasonable coordination of at least five legs. The "average time required for knock-down" and the "average duration of knock-down" apply only to flies that were knocked down, and should not be confused with values based on 50-per cent knock-down. Recovery often occurred after several hours and at times when it was not practical to make frequent observations; so it was sometimes necessary to express the average duration of knock-down as being between possible minimum and maximum values.

The pyrethrum solutions were made by diluting a commercial concentrate containing 20-per cent of pyrethrins to 0.4 per cent with deodorized kerosene. The accessory materials—piperonyl butoxide, piperonyl cyclonene, and the diallyl ester of succinic acid—were obtained from the Orlando, Florida, laboratory of this Bureau. They were used for separate applications as 4-per cent solutions in a solvent mixture containing 75 per cent of deoderized kerosene and 25 per cent of cyclohexanone. The solutions for combined applications were made in the same solvent mixture and contained 0.4 per cent of pyrethrins and 4 per cent of one of the accessory materials.

There was no noticeable difference in the size of drops picked up from any of the solutions by a given loop, and all the solutions appeared to spread equally well on the flies. The loop used in all the regular tests carried drops that measured 0.37 mm. in diameter when deposited in alcohol. These drops had a volume of 0.026 cu. mm., and when a 0.4-per cent solution was being used they contained about 0.1 microgram of pyrethrins. In some incidental tests a loop that carried a drop 0.17 mm. in diameter, or about 0.01 microgram of pyrethrins in a 0.4-per cent solution, was used. A drop from the larger loop spread over nearly the entire top of the thorax, over the mouth parts and lower portions of the head, or over a wide area around the thoracic spiracle. Drops from the smaller loop spread over areas only a few times wider than the thoracic spiracle.

RESULTS AND DISCUSSION.—The site of application may determine, to a large extent, the response to a given dose of pyrethrum. When applied to the top of the thorax, 0.1 microgram of pyrethrins knocked down only 40-per cent of the house flies, *Musca domestica* (L.) and 85-per cent of *Calliphora vomitoria* (L.), the average times required being 13 and 14 minutes, respectively (Table 1). The same dose applied to the mouth parts knocked down all flies of each species, and the average time required was only 1 minute. Complete knock-down was also obtained with both species when the dose was applied to the thoracic spiracle, but with house flies the time required was slightly longer (average 3 minutes).

The effectiveness of applications to the thoracic spiracle may have been due to the direct entrance of part of the solution into the trachea, whereas that of applications to the mouth parts may have been due to rapid penetration through the membranous covering of these structures. Incidental tests made with small numbers of insects indicate that other, but not all, membranes are readily penetrated. As little as 0.01 microgram of pyrethrins caused immediate knock-down of house flies when applied to the thin, colorless membranes on the neck and between the cocci. Ten times that dose (0.1 microgram), however, had no more effect when applied to the membranous bottom of the abdomen than when applied to the top of the thorax. Since the last two sites are relatively distant from large masses of nerve tissue, slow transport and loss during transport to the critical tissues may have been important factors.

There was delayed knock-down in both species when pyrethrum was applied to the top of the thorax. Although penetration through the thorax may have been slow in *Calliphora vomitoria*, it was probably fairly complete, because a rather high percentage of knock-down was finally obtained, and the duration of knock-down was about as long as that resulting from doses applied to other areas. In house flies the percentage of knock-down was low and the duration short. It is therefore likely that in this species there was considerable loss from detoxication before the material reached the site of action. Incomplete as well as slow penetration

might be considered a likely explanation for the ineffectiveness of doses applied to the top of the thorax, were it not for the results obtained when piperonyl butoxide was used with the pyrethrum.

The most conspicuous effect of either piperonyl butoxide or piperonyl cyclonene was to inhibit recovery from knock-down (Tables 2 and 3). This effect was nearly as great when one of these materials and pyrethrum were applied to different parts of the insect body as when they were mixed in the same solution. Without pyrethrum, neither of these materials had any visible effect at the dosages used. When used with pyrethrum, the symptoms appeared to be the same as those caused by pyrethrum alone. A third accessary material, diallyl succinate, was tested on house flies, but showed no significant effect when applied with pyrethrum.

The high degree of effectiveness of separated doses shows that external effects, such as enhancement of penetration or protection of the pyrethrum from oxidative destruction, cannot play more than a small part in the synergistic action of piperonyl butoxide or piperonyl cyclonene. Of the possible internal effects, conjugation within the insect body to form a third and highly toxic compound can probably be eliminated as unlikely to produce symptoms so nearly like those produced by pyrethrum alone. Provision of an internal aid to penetration should have decreased rather than increased the average time required for knock-down when the pyrethrum was applied to the top of the thorax.

Inhibition of recovery in itself suggests a damaged detoxifying mechanism. Unless such damage is very transitory, the agent causing it should be effective when applied before the toxin. This was found by Lindquist (1947) to be the case when certain piperonyl compounds were used as sprays, and similar results were obtained in this study. Recovery from knock-down was reduced in *Calliphora vomitoria* from 90 to 10-per cent, although the doses were separated in both space and time by applying piperonyl butoxide to one thoracic spiracle and pyrethrum an hour later to the other thoracic spiracle (Table 2). Piperonyl cyclonene applied to the mouth parts of 20 house flies an hour before the pyrethrum reduced recovery after knock-down from 90-per cent to 0, which is a somewhat greater effect than was obtained in another test when the two materials were applied together (Table 3).

When either of the two piperonyl compounds were applied to the same place as the pyrethrum, they were somewhat more effective in preventing recovery after knock-down than when they were applied to another place. This slight difference might have been due to some interaction of the compounds while they were still outside the insect, or it may be that the materials are more certain to reach their critical tissues when applied together, or at least to the same spot. If the detoxifying action blocked by these accessory materials is a function of some distant organ, such as the Malpighian tubules, it makes little difference where the doses are applied provided there is adequate penetration. If, however, the critical action of these piperonyl compounds and of pyrethrum is on intimately associated tissues or perhaps on the same cells, there will be an advantage in administering them together unless the piperonyl compounds are given in sufficient quantities to saturate all the critical tissues.

Investigation of the doses necessary to saturate the critical tissues with either of the piperonyl compounds was precluded by the exploratory nature of this study, but some incidental tests strongly suggest that a synergistic effect is achieved by their action on tissues that are located near those affected by pyrethrum. All of five *Calliphora* flies were knocked down by the minute dose of 0.01 microgram of pyrethrins applied to each tarsus, but all recovered. There was no recovery when 0.1 microgram of piperonyl butoxide was included with the pyrethrum, but 2 of 5 flies recovered when the larger dose of 1.0 microgram of piperonyl butoxide was applied to a thoracic spiracle an hour previously. In another case the low dose of 0.01 microgram of pyrethrins plus 0.1 microgram of piperonyl butoxide on the mouth parts of 5 house flies allowed no recovery. When the same materials were given in doses 10 times as great but with the accessory material applied to the abdomen, 1 of 5 flies recovered.

The results of these tests made with sublethal and barely lethal doses are reasonably consistent with the published descriptions of the effects of pyrethrum

and certain piperonyl compounds. As a working hypothesis, it may be useful to consider that:

1. The site of critical action of pyrethrum and of piperonyl butoxide and piperonyl cyclonene takes place on the nerves but the two types of compounds affect different parts of the cells.
2. Piperonyl butoxide, piperonyl cyclonene, and perhaps other piperonyl compounds that inhibit recovery from knock-down, cause long-lasting damage to the nerve cell bodies, whereas pyrethrum affects the fibers.
3. The damage to the cell bodies may not noticeably impair the functioning of the nerve fibers, but it seriously interferes with repair of damage done to them by pyrethrum, and to obtain supplementary action it is necessary for both types of chemicals to act on the same cells.

This concept becomes of particular importance when minimal doses are being considered. Very minute amounts of pyrethrum taken up through the tarsi may incapacitate an insect by blocking a small number of nerve cells in the confined spaces of the legs. Since the amount of pyrethrum that will do this is much less than the amount necessary to produce an effective concentration in the insect as a whole, the cells will subsequently be bathed in hemolymph that is relatively free of toxin. Recovery, then, will be both quick and certain unless the affected cells have been rendered incapable of repair.

SUMMARY.—A simple and rather fast technique is described for administering predetermined doses of insecticides to selected areas on adult flies. The fly is immobilized by gently pressing it between a cotton pad and a cupped wire screen. A droplet of insecticidal solution is picked up on a fine wire loop of suitable size and thrust through one of the openings of the screen to deposit it on the desired part of the fly.

The effect of a given dose of pyrethrum in refined deodorized kerosene depends largely on the area to which it is applied. When placed on the top of the thorax, 0.1 microgram of pyrethrins knocked down only 40-per cent of the house flies, *Musca domestica* (L.), and 85-per cent of *Calliphora vomitoria* (L.), the average times required being 13 and 14 minutes, respectively. The same dose required an average time of only 1 minute and knocked down 100-per cent of all the flies when applied to the mouth parts.

The most conspicuous effects of the compounds piperonyl butoxide and piperonyl cyclonene are, as has been previously shown by spray techniques, to inhibit recovery from knock-down by pyrethrum. When either of these compounds is applied to a part different from that on which pyrethrum is applied, the effect is nearly as great as that produced by the same compound applied together with the pyrethrum.

Pyrethrum plus either of the two piperonyl compounds applied to the top of the thorax increased the time required for knock-down as well as the per cent of knock-down.

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PURDUE PEST CONTROL OPERATOR'S CONFERENCE

The thirteenth annual Pest Control Operators' Conference was held at Purdue University, February 7–10, 1949. The program involved the biology of insects, pest control principles, ectoparasites, problems of termite, fly, and rodent control, insecticides, and food industry problems.

Effect of Temperature and Humidity on the Toxicity of Certain Insecticides[1]

J. C. Gaines and H. A. Dean, *Texas Agricultural Experiment Station, College Station*

Cage toxicity tests were conducted in both the laboratory and field to determine the effect of temperature and humidity on several insecticides, some of which are used extensively for the control of cotton insects. Fleck & Haller (1944 and 1945) determined that small quantities of compounds found in insecticidal mixtures act as catalysts and cause decomposition of DDT at certain temperatures. Dustan (1947) showed experimentally that the mortality by both contact and stomach action of DDT steadily decreased as the temperature increased from 60° to 95° F. Investigations by Lindquist *et al.* showed that temperature has a similar effect on the toxicity of DDT to houseflies.

Chisholm & Koblitsky (1947) show that sunlight decreases the toxicity of DDT. Field experiments conducted by Gaines *et al.* (1948) showed that DDT dust was not effective in controlling thrips or harlequin bugs in certain years, perhaps due to high temperature and low humidity. Since there is considerable evidence that the toxicity of DDT decreases as the temperature increases, it was deemed advisable to determine the effect of temperature and humidity on the toxicity of other insecticides to the boll weevil, *Anthonomus grandis* Boh.

Methods.—The dusting chambers, guns and air pump used in these tests were similar to those described by Waters in a publication edited by Campbell & Moulton (1943) and by Ivy (1944).

A celluloid dusting cylinder 40 inches high and 9.5 inches in diameter was used in the laboratory tests. This size cylinder mounted on a cabinet accommodated either potted plants approximately 10 inches high or the freshly cut tops from cotton plants with stems placed in jars of water. Under moderate temperatures, the cut plants served as suitable weevil food for a period of 5 days. Under high temperature or with low relative humidity the use of potted plants was necessary.

The plant was placed in the cabinet under the celluloid cylinder for dusting. A measured quantity of insecticide was discharged from a glass gun into the top of the cylinder by means of an air pump apparatus. The dust was allowed to settle 5 minutes and the potted plants or those in jars of water were immediately removed to cages 6 by 6 by 12 inches in size. This type cage was constructed with a removable bottom. A piece of plywood with a center hole was cut in half, the two pieces fitted together around the base of the plant and rested on the pot. The cage proper rested on the boards or bottom, encasing the stem of the plant. Three sides of the cage were covered with plastic screen and the fourth side with glass, which fitted into grooves to form a sliding door fitting flush against the solid top, thus affording an entry into the cage for introduction of weevils and daily examination for dead individuals. Fifteen weevils were released into each cage.

Due to the large size of the cotton plants in the field cage tests, a larger cylinder and gun were used and a tank, equipped with a gauge and a pressure regulating valve furnished the air blasts. As in laboratory tests, the dust was discharged into the top of the cylinder and allowed to settle for a period of 5 minutes. The cylinder was then removed and cages were placed over the dusted plants. These cages were constructed on a larger scale, 24 by 24 by 24 inches, in order to accommodate the larger plants. They were mounted on stands 10 inches above the ground and were similar in design to the above described cages, with the exception of being covered on all sides and the top with screen wire. A door was also made in one side to provide for examinations and the entry for 25 weevils in each cage.

The weevils used in experiment 1 and 2, herein designated as laboratory-reared, emerged from punctured squares which had been collected in the field and placed in cloth covered cages. The emerging weevils were attracted to glass vials inserted in the sides of the cages. At regular intervals the emerging weevils were

[1] Technical Contribution No. 1180 Texas Agricultural Experiment Station in Cooperation with the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture.

removed from the vials and allowed to feed on fresh cotton blooms before being used in a test.

Survival records were made daily for a period of 5 days. The same number of replicates of each insecticide was included in each experiment making the tests comparable from both the standpoint of population and that of the condition under which the test was conducted. Usually 4 replicate cages were included for each dosage of insecticide and 4 untreated cages served as checks. A minimum of 5 different dosages, which included a total of 20 cages or 300 individuals. were used to establish each dosage-mortaltiy curve. Abbott's formula was used to calculate the percentage control. The dosages were calculated to the acre-basis and changed to logarithms and the percentage-mortalities were changed to probits for caculating the dosage-mortality curves. The regression lines were calculated according to Bliss' (1938) method. The regression coefficient or the slope of each line, the amount by which the mortality is increased for every unit increase in dosage, is shown in tabular form.

Hygrothermographs were used to record the temperature and relative humidity during the duration of each experiment.

Cabinets containing about 23 cu. ft. of space constructed to maintain a constant temperature and humidity were used to study the effect of humidity. Each cabinet was of sufficient size to allow 20 cages in a series, 4 replicates of each insecticide and checks. The cages placed in the cabinets were in complete darkness during the test period except for a short interval each day while examinations for dead weevils were made.

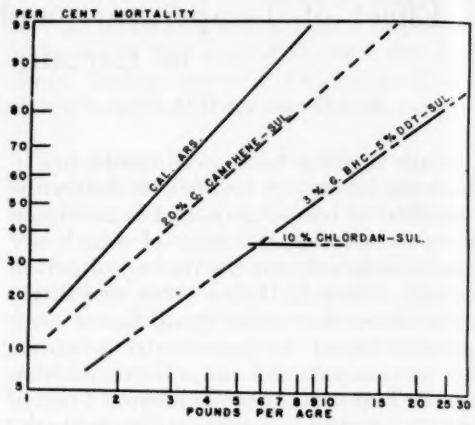

FIG. 2.—Dosage-mortality curves for the toxicity of the insecticides indicated to laboratory-reared weevils in experiment 2 conducted in the field at average daily temperatures ranging from 73 to 107° F. and average daily relative humidities ranging from 24 to 90 per cent.

RESULTS.—Experiment 1, figure 1, was conducted in the laboratory using laboratory-reared weevils. The average daily temperatures during the test period ranged from 84 to 92° F. and the average daily relative humidities ranged from 44 to 63 per cent. The median lethal dose (MLD) and regression coefficient are given for each dosage-mortality curve in

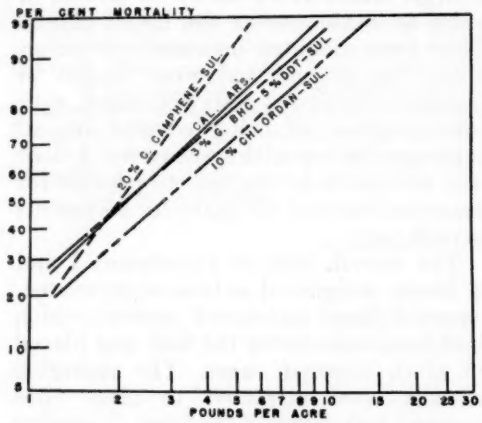

FIG. 1.—Dosage-mortality curves for the toxicity of the insecticides indicated to laboratory-reared weevils in experiment 1 conducted in the laboratory at average daily temperatures ranging from 84 to 92° F. and average daily relative humidities ranging from 44 to 63 per cent.

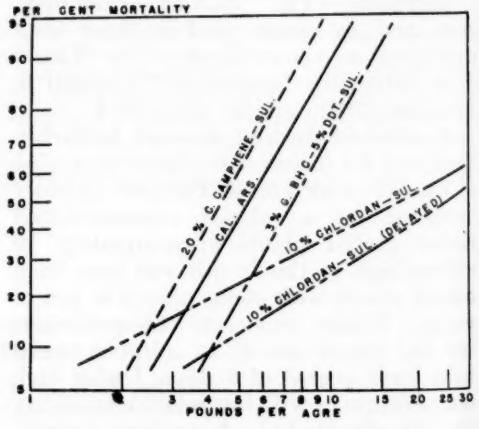

FIG. 3.—Dosage-mortality curves for the toxicity of the insecticides indicated to field-collected weevils in experiment 3 conducted in the laboratory at average daily temperatures ranging from 78 to 93° F. and average daily relative humidities ranging from 34 to 70 per cent.

Table 1.—Median lethal doses in pounds per acre and regression coefficients of dosage-mortality curves for each insecticide tested against the boll weevil under the conditions indicated at College Station, Texas.

Treatment	Laboratory-Reared Weevils				Field-Collected Weevils			
	Laboratory[1]		Field[2]		Laboratory[3]		Greenhouse[4]	
	MLD	Slope of Line[5]	MLD	Slope of Line	MLD	Slope of Line	MLD	Slope of Line
Calcium arsenate	2.2	2.7	2.5	3.0	5.4	4.5	2.0	0.6
20% Toxaphene-sulphur	1.9	3.9	3.7	2.4	4.4	4.7	3.9	0.4
3% Gamma benzene hexachloride-5% DDT-sulphur	2.2	2.5	9.1	2.0	8.6	4.7	7.5	3.0
10% Chlordan-sulphur	2.8	2.3	[7]		18.0	1.4	23.1	1.0
10% Chlordan-sulphur[6]					27.6	1.7	49.1	1.5

[1] Experiment 1 was conducted in the laboratory, ave. daily temp.: Max. 92°, Min. 84°; humidity: Max. 63%, Min. 44%.
[2] Experiment 2 was conducted in the field, ave. daily temp.: Max. 107°, Min. 73°; humidity: Max. 90%, Min. 24%.
[3] Experiment 3 was conducted in the laboratory, ave. daily temp.: Max. 93°, Min. 78°; humidity: Max. 70%, Min. 34%.
[4] Experiment 4 was conducted in a greenhouse but shaded from direct sunlight, ave. daily temp.: Max. 108°, Min. 76° and relative humidity Max. 87%, Min. 27%.
[5] Regression coefficient.
[6] Weevils released on plants 24 hours after the dust was applied.
[7] At doses up to 12 pounds per acre the mortality was 36 per cent.

table 1. The MLDs for 20 per cent toxaphene, calcium arsenate, 3 per cent gamma benzene hexachloride-5 per cent DDT and 10 per cent chlordan were 1.9, 2.2, 2.2 and 2.8 pounds per acre, respectively. The slope of the curve for each insecticide, as measured by the regression coefficient, was approximately the same with the exception of the 20 per cent toxaphene, in which case a greater toxicity was indicated above the 50 per cent point.

Experiment 2, figure 2, was conducted in the field, also using laboratory-reared weevils. The average daily temperatures in the cages during the test period ranged from 73 to 107° F. and the daily average relative humidities ranged from 24 to 90 per cent. The MLDs for calcium arsenate, 20 per cent toxaphene and 3 per cent gamma benzene hexachloride-5 per cent DDT were 2.5, 3.7 and 9.1 pounds per acre, respectively. The slope of the curve for each insecticide was about the same except in the case of calcium arsenate, which grew slightly steeper, indicating a greater toxicity at mortalities above the 50 per cent point. The 10 per cent chlordan gave only a maximum of 36 per cent mortality with dosages ranging from 6 to 12 pounds per acre.

Experiment 3, figure 3, was conducted in the laboratory using field-collected weevils. The average daily temperatures during the tests period ranged from 78 to 93° F. and the average daily humidities ranged from 34 to 70 per cent. The MLDs for 20 per cent toxaphene, calcium arsenate and 3 per cent gamma benzene hexachloride-5 per cent DDT and 10 per cent chlordan were 4.4, 5.4, 8.6 and 18.0 pounds per acre, respectively. The slopes of the curves for the first three materials listed were nearly the same and all were considerably steeper than the 10 per cent chlordan curve. In tests from which the curve designated 10 per cent chlordan (delayed) was calculated, the weevils were released 24 hours after the plants had been dusted. This delay reduced the toxicity, as indicated by the MLD of 27.6 pounds per acre, as compared to 18.0 pounds per acre in tests with the same material and when the weevils were released immediately after dusting.

Experiment 4, figure 4, was conducted in the greenhouse, also using field-collected weevils. The cages were shaded and the temperatures kept comparable to the field temperatures during the test period of experiment 2. The average daily temperatures during the test period ranged from 76 to 108° F. and average daily humidities ranged from 27 to 87 per cent. The MLDs for calcium arsenate, 20 per cent toxaphene, 3 per cent gamma benzene hexachloride-5 per cent DDT and 10 per cent chlordan were 2.0, 3.9, 7.5 and 23.1 pounds per acre, respectively. The slopes of the curves were also greatly affected by the high temperatures, thus indicating less toxicity at mortalities above the 50

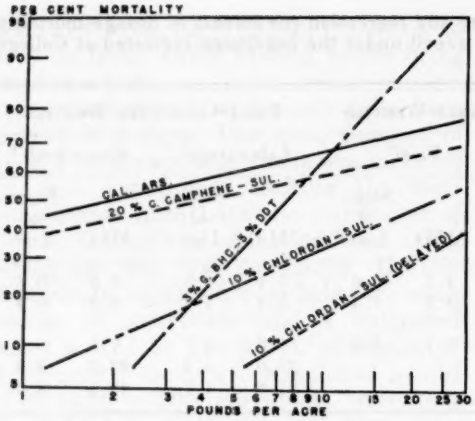

FIG. 4.—Dosage-mortality curves for the toxicity of the insecticides indicated, to field-collected weevils in experiment 4 conducted in the greenhouse at average daily temperatures ranging from 76 to 108° F. and average daily relative humidities ranging from 27 to 87 per cent.

per cent point. The toxicity of 10 per cent chlordan was reduced in the tests in which the weevils were released 24 hours after the plants had been dusted.

Experiments 5, 6 and 7, tables 2, 3 and 4, respectively, were conducted in cabinets in a laboratory using field-collected weevils. The temperature was maintained at 85° F. in all experiments, while the humidity was maintained at 80 per cent in experiment 5, 70 per cent in experiment 6 and 45 per cent in experiment 7. Humidity affected the toxicity of all the materials used. The toxicity was 2 to 4 times as high at 45 per cent relative humidity as it was under the conditions of 80 per cent humidity.

Experiment 8, table 5, was conducted in the laboratory using field-collected weevils. The average daily temperatures during the test period ranged from 78 to 93° F. and the average daily relative humidities ranged from 34 to 70 per cent. In the tests in which weevils were released 24 hours after the plants were dusted, the toxicity of 20 per cent toxaphene was reduced. Exposure to wind (2720 accumulated feet per hour) and sun for 4 hours likewise reduced the toxicity of this material.

SUMMARY.—In cage tests with boll weevils, the toxicity of calcium arsenate

Table 2.—Boll weevil mortality following treatments as indicated in a cabinet maintaining a constant temperature of 85° and relative humidity of 80 per cent at College Station, Texas.

TREATMENT	POUNDS PER ACRE	REPLICATE CAGES	TOTAL INSECTS	MORTALITY, PER CENT
Calcium arsenate	6	4	61	0.0
	10	4	64	47.3
	14	4	48	54.9
	16	4	63	71.4
Ave. or total	11.5	16	236	43.4
20 per cent Toxaphene-sulphur	14	4	62	14.2
	16	4	61	50.8
	24	8	131	22.2
Ave. or total	18	16	254	29.1
20 per cent Chlordan-sulphur	15	4	60	4.8
	16	4	63	23.8
	24	8	127	0.7
Ave. or total	18.3	16	25.0	9.8

Table 3.—Boll weevil mortality following treatments as indicated in a cabinet maintaining a constant temperature of 85° and relative humidity of 70 per cent at College Station, Texas.

TREATMENT	POUNDS PER ACRE	REPLICATE CAGES	TOTAL INSECTS	MORTALITY, PER CENT
Calcium arsenate	4	4	60	21.8
	6	4	58	47.4
	8	4	62	56.4
	10	4	60	46.2
Ave. or total	7.0	16	240	43.0
20 per cent Toxaphene-sulphur	2.5	4	60	12.2
	5	4	58	36.1
	8	4	52	45.6
	10	4	61	50.3
Ave. or total	6.4	16	231	36.1
20 per cent Chlordan-sulphur	2.5	8	115	11.0
	4	8	112	26.0
	6	8	124	34.2
	8	8	102	24.8
Ave. or total	5.1	32	452	24.0

Table 4.—Boll weevil mortality following treatments as indicated in a cabinet maintaining a constant temperature of 85° and relative humidity of 45 per cent at College Station, Texas.

TREATMENT	POUNDS PER ACRE	REPLICATE CAGES	TOTAL WEEVILS	MORTALITY, PER CENT
Calcium arsenate	1	4	59	13.3
	2	4	63	52.8
	3	4	62	66.2
	4	4	64	66.2
Ave. or total	2.5	16	248	49.6
20 per cent Toxaphene-sulphur	4	4	64	38.1
	6	4	65	35.6
	8	4	64	39.8
	14	4	61	32.3
Ave. or total	8.0	16	254	36.5
20 per cent Chlordan-sulphur	4	4	67	22.1
	6	4	68	32.3
	8	4	69	31.5
	10	4	62	36.6
Ave. or total	7.0	16	266	30.6

Table 5.—Boll weevil mortality following dust applications of 20 per cent toxaphene-sulphur under conditions as indicated in tests at College Station, Texas.

CONDITION	POUNDS PER ACRE	REPLICATE CAGES	TOTAL WEEVILS	CONTROL, PER CENT
Weevils released immediately after plants were dusted	6	4	48	59.1
Weevils released 24 hrs. after plants were dusted	6	4	60	38.7
Weevils released after dusted plants had been exposed to sun 4 hrs.	6	4	60	38.8
Weevils released 24 hrs. after plants were dusted and exposed to sun 4 hrs.	6	3	45	0

remained more nearly the same under all temperatures than did that of any of the organic insecticides used. However, the toxicity of this material was reduced both by high temperature and high humidity. Laboratory-reared weevils were considerably more susceptible to the organic insecticides than were field-collected weevils. High temperature and high humidity had less effect on the toxicity of 20 per cent toxaphene than on that of the other organics. However, the toxicity of this material was reduced appreciably by high temperatures. The toxicity of 3 per cent gamma benzene hexachloride-5 per cent DDT was also reduced by high temperatures necessitating dosages as great as 30 pounds per acre in order to obtain a high mortality. The toxicity of 10 per cent chlordan was greatly reduced by high temperatures. At the higher temperatures it was necessary to use 23 pounds of this material per acre in order to effect even a 50 per cent mortality. In tests in which the weevils were released 24 hours after the plants were dusted, the toxicity of chlordan was further reduced.

In tests conducted at a constant temperature, high humidity reduced the toxicity of calcium arsenate, 20 per cent toxaphene and 20 per cent chlordan.

The delay in releasing weevils 24 hours after dusting the plants and the exposure of the dusted plants to the sun for 4 hours reduced the toxicity of 20 per cent to toxaphene.

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CURRENT NOTES

Curtis W. Wingo, on leave of absence from the Department of Entomology, University of Missouri, is doing graduate work at Iowa State College and in his absence George W. Thomas, who will come up for the Master's degree in June is substituting for him.

Howard T. Griep, who received the Master's degree in February from the University of Missouri has accepted appointment with the California Spray Chemical Company with headquarters in Lincoln, Nebraska.

On March 14, 1949, Dr. L. A. Stearns, Head of the Department of Entomology, University of Delaware, addressed a group of 400 officers at the Chemical Corps School, Army Chemical Center, Maryland, on the subject "Iran, Critical Point in the Unsettled Middle East." This was one of the lectures in the orientation series for officers of the Chemical Corps School, in which speakers are being provided by the University of Delaware, University of Maryland, and other institutions in this area.

Toxicity to Fabric Insects and Resistance to Washing and Dry Cleaning of Six Chlorinated Hydrocarbon Insecticides

H. LAUDANI and F. O. MARZKE, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

A number of the new chlorinated hydrocarbon insecticides are being used extensively for the control of fabric insects and a few as the active ingredients of commercial mothproofing compounds. Very little has been published on the toxicity of these insecticides to fabric pests and their resistance to washing and dry cleaning when applied to woolens.

Laboratory tests were conducted at Savannah, Ga., to determine the degree of protection rendered, the mortality obtained, and the retention qualities after washing and dry cleaning of DDT, dichlorodiphenyl dichloroethane, methoxychlor, toxaphene, benzene hexachloride, and chlordan.

TECHNIQUE USED.—Botany-style No. 315 broadcloth containing 100 per cent of wool, which is considered the standard test fabric by the American Association of Textile Chemists and Colorists, was used exclusively as the test fabric. Samples of this cloth were impregnated with the insecticides at the following concentrations: 0.5, 1, 1.5, 2, and 3 per cent by weight of the cloth. After treatment the specimens were thoroughly aired for 7 days to remove all volatile constituents.

One series of treated fabrics was exposed to larvae of the black carpet beetle, *Attagenus piceus* Oliv., without further treatment; a second series after the material had been subjected to one, two, and three washings; and the third series after it had received one, two, and three dry cleanings.

A machine that made 42 revolutions per minute was used for both the washing and the dry cleaning. The materials were washed for 30 minutes in a solution which contained 5 grams of soap per litre of water at 40° C. and at the rate of one part of material to 50 parts of liquid. They were then rinsed for 10 minutes, the excess water was rolled out, and the cloth hung vertically to dry. The dry-cleaning process consisted in placing two pieces of fabric 1 by 2 inches in 100 ml. of Stoddard's solvent and agitating them for 20 minutes at 32° C. The excess solvent was then rolled out and the cloth laid on a horizontal screen to dry at room temperature. When dry the fabric was pressed with a steam iron and allowed to dry another hour before being tested.

The treated cloths were exposed individually in petri dishes to 10 carpet beetle larvae for 28 days. In such an exposure the insects had the choice of staying on or off the treated cloth. The test insects were 3 to 5 months old or weighed 4.5 to 6.5 mg. Four replicates were used, and untreated checks were included in each test. The petri dishes holding the test insects were stored during the exposure period in a room held at a constant temperature of 80° ± 2° F. and a relative humidity of 60 per cent ± 5 per cent.

The results were evaluated according to (1) mortality, (2) visual damage, and (3) weight of frass per larva. The visual damage is expressed as the amount of nap feeding, which is the shearing of the nap or pile, and as the warp feeding, which is the breaking of the fibers resulting in holes in the cloth. The sliding scale used for expressing the nap and warp damage (Table 1) is 0 to 5, with 0 as no damage and 5 as almost complete destruction of the cloth specimens.

RESULTS.—Before discussing the results it is necessary to mention that these tests were conducted under somewhat critical conditions. The test insect, the black carpet beetle larva, is the most resistant of the fabric insects and one of the heaviest feeders. Moreover, the test insects had no choice of food, since only the treated cloths were present in the petri dishes.

In the tests in which the impregnated cloths were exposed without further treatment, the six insecticides showed the following order of decreasing toxicity: Chlordan, benzene hexachloride (6 per cent gamma), toxaphene, DDT, dichlorodiphenyl dichloroethane and methoxychlor. However, the relative protective value rendered to the cloth by these in-

Table 1.—Visual damage from black carpet beetle larva to cloth impregnated with six chlorinated hydrocarbon insecticides.

Insecticide	Concentration (Per Cent by Weight of Cloth)	None		Number of Washings						Number of Dry Cleanings					
				1		2		3		1		2		3	
		Nap	Warp	Nap	Warp	Nap	Warp	Nap	Warp	Nap	Warp	Nap	Warp	Nap	Warp
DDT	0.5	0	0	0	0	3–4	3	4	4	4	4	4	3–4	4	3–4
	1	0	0	0	0	3	2	3	3	3	2–3	3	3	3–4	2–4
	1.5	0	0	0	0	1	0–1	2	2	2	1–2	3	3	3–4	2–3
	2	0	0	0	0	1	0–1	1–2	1–2	1	1	4	3–4	4	3
	3	0	0	0	0	1	0–1	1	0–1	0	0	3	2–3	4	4
Dichlorodiphenyl dichloroethane	0.5	0	0	3	3	4	3	4	4	3–4	3	4	3–4	3–4	3
	1	0	0	2–3	1	4	3–4	4	3–4	3	3	4	3–4	4	3
	1.5	0	0	1	0	3	2–3	3–4	3	3–4	2–3	4	4	4	3
	2	0	0	0–1	0	2	1–2	2–3	2	2–3	1–2	4	3	3–4	3–4
	3	0	0	0–1	0	1–2	0–1	2	1	1–2	1	4	3–4	4	3–4
Methoxychlor	0.5	1	0–1	3–4	2–3	4	4	4	4	4	3–4	3–4	3	4	3–4
	1	0	0	1	0–1	4	3	4	4	3–4	3	3–4	3	3–4	3
	1.5	0	0	0	0	3–4	3	4	3	4	4	4	4	4	3–4
	2	0	0	0	0	3	2–3	4	3	3	2–3	3–4	3–4	4	3–4
	3	0–1	0	0	0	2	1–2	2–3	2–3	3	2	3–4	2–4	4	3–4
Toxaphene	0.5	1	0	2	1	3–4	2–3	3–4	3	3	2–3	4	3–4	4	4
	1	1	0	1	0	2–3	1–2	3	2	3	2	3–4	3	4	3
	1.5	1	0	0	0	2	1	2	2	3	2	4	3–4	4	3
	2	1	0	0	0	1–2	1	2	1	3	2	3–4	3–4	4	3
	3	2	0	0	0	1	0–1	1	0–1	2–3	1–2	3	2–3	3–4	3
Benzene hexachloride (6% gamma)	0.5	1–2	0–1	4	3–4	4	4	4	3–4	3	3	3–4	1–2	3	2–3
	1	0–1	0	3–4	3	4	4	4	4	3	2	3	2	3	2
	1.5	0–1	0	2	2	4	4	4	4	2	0–1	3	1	3	0–1
	2	0–1	0–1	1	1	4	4	4	4	2	0–1	2–3	0–1	3	0–1
	3	0–1	0	1	0	2	2	2	2	2	0–1	3	1–2	3	1–3
Chlordan	0.5	0–1	0–1	4	2–3	4	3	4	4	3	3	3–4	2–3	4	2–4
	1	0	0	2	0–1	3	2–3	3	3	2	2	2	2	3	2
	1.5	0	0	1	1	1–2	1	2–3	2	1–2	1	2–3	2	3	2
	2	0	0	0–1	0	1–2	1	2	1–2	2	1–2	1–2	1	2	2
	3	0	0	0	0	1	1	1	1	1–2	1	2	1	2	1–2
Check (untreated)		4	4	4	3–4	4	4	4	3–4	4	4	4	3–4	4	4

secticides did not correspond to the mortality obtained. DDT offered the greatest protection, followed in order by chlordan, toxaphene, dichlorodiphenyl dichloroethane, methoxychlor, and benzene hexachloride.

The mortalities obtained at concentrations of 0.5 to 3 per cent were as follows: Chlordan 75 to 100 per cent, benzene hexachloride 0 to 100 per cent, toxaphene 25 to 52 per cent, DDT 15 to 47 per cent, dichlorodiphenyl dichloroethane 3 to 14 per cent, and methoxychlor 1 to 6 per cent.

With only a few exceptions, the visual damage was directly correlated with the frass weight. Therefore, only the former will be considered (Table 1). There was no nap or warp damage on the cloths impregnated with DDT and dichlorodiphenyl dichloroethane at any of the concentrations tested. At the 0.5 per cent concentration, light nap and warp feeding was observed on the cloths treated with chlordan and methoxychlor. At the higher concentrations the former permitted no feeding and the latter had only one case of very light damage. Light nap feeding took place on all the cloths treated with toxaphene, and those treated with benzene hexachloride had scattered light nap and warp damage.

Washing and dry cleaning reduced the toxicity of the treated cloths substantially, and in most cases destroyed the protective value of these insecticides completely. After two washings or three dry cleanings, the mortality dropped to zero except in dishes containing cloths impregnated with toxaphene or chlordan, which caused limited mortality at the high concentrations.

DDT at all concentrations and methoxychlor and toxaphene at the higher concentrations were the only insecticides that gave complete protection to the cloth after one washing. None of them gave complete protection after two washings, although limited protection was obtained with DDT, toxaphene, and chlordan after the second and third wash. The 3-per cent concentration of DDT was

the only treatment that offered complete protection after one dry cleaning.

SUMMARY.—Woolen cloths impregnated with six chlorinated hydrocarbon insecticides at concentrations ranging from 0.5 to 3 per cent by weight of cloth were exposed to larvae of the black carpet beetle, *Attagenus piceus* Oliv., for 28 days. The following mortalities were obtained: Chlordan 75 to 100 per cent; benzene hexachloride (6 per cent gamma) 0 to 100 per cent; toxaphene 25 to 52 per cent; DDT 15 to 47 per cent; dichlorodiphenyl dichloroethane 3 to 14 per cent; and methoxychlor 1 to 6 per cent. According to the visual damage and frass weight noted during these tests, the greatest protection to woolen cloth was obtained with DDT, dichlorodiphenyl dichloroethane, chlordan, methoxychlor, toxaphene, and benzene hexachloride in the order named. Washing and dry cleaning seriously affected the toxicity and the protective value of all the treated cloths, with the exception of those treated with DDT, which resisted one washing at all concentrations.

Fumigating Properties of Several New Insecticides

ROBERT A. HOFFMAN and ARTHUR W. LINDQUIST, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

During the early experimental work with DDT in 1943, laboratory tests showed that this compound did not act as a fumigant on house flies or mosquitoes. Later it was found that technical benzene hexachloride had a pronounced effect on these insects when they were exposed in a 25-cubic-foot glass cage on the floor of which had been placed 5 grams of the technical product. Srivastava & Wilson (1947) reported on the fumigating effect of benzene hexachloride on several stored-product insects and pea aphids. Other investigators have reported that this material acts as a fumigant, although little, if any, of the data has been published.

The fumigating action of a contact insecticide resulting from space sprays or residual treatments greatly enhances its value in the control of certain insects, particularly those inhabiting enclosed spaces such as homes, warehouses, and similar installations. Contact insecticides having fumigating action may also be more effective in controlling some of the external parasites on animals having long hair or wool.

Laboratory tests were conducted in 1947 to determine the fumigating effect of various new insectides, with the house fly *Musca domestica* L., as the test insect. The insecticides tested were DDT, several isomers of benzene hexachloride, chlordan, chlorinated camphene, dichlorodiphenyl dichloroethane, the fluorine analog of DDT, and parathion. The materials were applied as residual treatments, and observations were made on the duration of their fumigation action.

METHODS.—Four wide-mouth quart jars, two treated and two untreated, were used in each test. Each jar contained 61 cubic inches of space and had a surface area of 0.6 square foot. The treated jars were coated on the inside with acetone solutions of the various chemicals. The compounds (technical grade) were applied at the rates of 10 and 100 mg. per square foot, equivalent respectively to 6 and 60 mg. per jar. The jars were stored upright and left uncapped at room temperatures between tests.

Reared 3 to 5-day-old house flies were used. The testing procedure consisted of placing an untreated jar containing 50 to 75 flies mouth-to-mouth over a treated jar, and a treated jar over an untreated jar containing the same number of flies. A clean 16-mesh wire screen was placed between the jars to prevent the flies from coming in contact with the treated surface. With this arrangement it was possible to determine whether the vapors were heavier or lighter than air by noting differences in knock-down or mortality of the flies.

Flies were exposed at irregular periods for several months after the jars were treated. Exposure was continued for 6 hours or until all the flies had been knocked down. After 6 hours the flies were transferred to another clean container, given water, and held for a mortal-

Table 1.—Results of fumigation tests against the house fly with several new insecticides at the rate of 100 mg. per square foot. Average of 2 or 3 replicates, each with 50 to 75 flies. Knock-down time and 24-hour mortality after maximum of 6-hour exposure on various days after treatment.[1]

Chemical	Knock-Down Time in Minutes After Indicated Number of Days						Per Cent Mortality After Indicated Number of Days					
	One-half Day	Days					One-half Day	Days				
		49	84	145	211	307		49	84	145	211	307
Benzene hexachloride (95 per cent gamma)	24	114	85	200	248	(91%)	100	100	100	100	100	100
Technical (12.8% gamma)	27	200	253	(31%)	0	(2%)	100	100	100	75	16	14
Parathion	103	316	(96%)	(96%)	[2]	(100%)	100	100	100	100	100	100
Chlordan	95	(78%)	(98%)	(15%)	[2]	(2%)	100	100	100	98	91	47
Fluorine analog of DDT	205	255	206	(44%)	(5%)	—	100	100	100	100	98	—
Dichlorodiphenyl dichloroethane	(26%)	(79%)	(27%)	(33%)	(8%)	(0)	78	100	46	37	16	9
Toxaphene	(22%)	(3%)	(60%)	(41%)	(0)	(0)	97	66	70	78	28	20
DDT	(0)	—	—	—	—	—	0	—	—	—	—	—
Untreated check	(10%)	(0)	(4%)	(7%)	(4%)	(0)	10	3	8	10	4	4

[1] If complete knock-down did not occur during the 6-hour exposure period, the tests were terminated. The figures in parentheses give the percentage knock-down at that time.
[2] No record.

ity count at 24 hours. All tests were run at room temperature (75° to 80° F.), and were replicated two or three times. The jars used for holding or exposing flies were washed in acetone between tests, so as to prevent any possible contamination by the chemicals.

RESULTS.—In general, the results obtained with the flies in the two positions were similar, an indication that the fumes produced by the chemicals were capable of filling an enclosure whether it was above or below the treatment. Only the results of the tests conducted with flies exposed above the treated containers are presented in tables 1 and 2. Many tests were made, but the tables include only the data from selected test periods.

The knock-down was usually more rapid when the flies were exposed to the 100-mg. dosage than when exposed to the 10-mg. dosage. Gamma benzene hexachloride gave the fastest knock-kown of all the materials and caused complete 24-hour mortality of flies during the entire 307-day test. Parathion also caused complete mortality of flies, but the percentage of flies knocked down at 6 hours was erratic. Technical benzene hexachloride, chlordan, parathion, and the fluorine analog of DDT consistently gave 100 per cent or near 100 per cent mortality in 24 hours during the first 145 days. Chlorinated camphene and TDE gave the slowest knock-down and generally lower 24-hour mortalities than the other materials. Tests were also conducted with the alpha, beta, and delta isomers of benzene

Table 2.—Results of fumigation tests against the house fly with several new insecticides at the rate of 10 mg. per square foot. Averages of 2 or 3 replicates, each with 50 to 75 flies. Knock-down time and 24-hour mortality after maximum of 6-hour exposure on various days after treatment.[1]

Chemical	12 Hours		7 Days		43 Days		82 Days	
	Knock-Down Time	24-Hour Mortality	Knock-Down Time	24-Hour Mortality	Knock-Down Time	24-Hour Mortality	Knock-Down Time	24-Hour Mortality
	Minutes	*Per Cent*	*Minutes*	*Per Cent*	*Minutes*	*Per Cent*	*Minutes*	*Per Cent*
Gamma benzene hexachloride (95% gamma)	31	100	66	100	124	100	(20%)	27
Technical benzene hexachloride (12.8% gamma)	56	100	170	100	241	100	(11%)	26
Parathion	168	100	202	100	(95%)	100	(41%)	87
Chlordan	125	100	267	100	(8%)	50	(13%)	22
Dichlorodiphenyl dichloroethane	(5%)	100	(43%)	96	(42%)	75	(5%)	32
Toxaphene	(39%)	100	(52%)	100	(52%)	83	(29%)	29
Untreated check	(10%)	10	(0)	10	(6%)	0	(6%)	9

[1] See footnote 1, table 1.

hexachloride (results not shown), but none of these isomers showed marked fumigating action.

At the 10-mg. dosage the duration of effectiveness of the various materials was markedly shorter than at the higher dosage, but gamma and technical benzene hexachloride and parathion caused 100 per cent mortality after 43 days. None of the compounds caused high mortality on the eighty-second day.

After 90 days flies were exposed in the treated jars to determine the effectiveness of the residues as contact treatments. In the jars treated with 10 mg. of gamma and technical benzene hexachloride, only partial kill was obtained in 24 hours. The moderately effective fumigants, dichlorodiphenyl dichloroethane and chlorinated camphene, however, gave 100 per cent knock-down as contact insecticides in 43 and 125 minutes, respectively. Parathion gave complete knockdown in 30 minutes.

It is concluded from these tests that most of the new insecticides provide insecticidal action by fumigation as well as by contact.

It is apparent that, when chemical residues are being tested for their contact effect on insects, consideration should be given to the part that the fumes may play in giving kills. In practical insect control in closed or nearly closed spaces, materials showing both contact and fumigating action may in general give better results; therefore, tests under practical conditions involving various economic species should be considered. For testing these materials under laboratory conditions, it might be advisable to design test containers in such a way as to minimize the effect of the fumes.

SUMMARY.—Laboratory tests were conducted to determine the fumigating effect of various new insecticides on house flies (*Musca domestica* L.). The insecticides used were DDT, several isomers of benzene hexachloride, chlordan, chlorinated camphene, parathion, TDE, and the fluorine analog of DDT.

At a dosage of 100 mg. per square foot all the new materials except TDE and chlorinated camphene caused complete kill of flies within 24 hours after a 6-hour exposure to the vapors of the chemicals. These two compounds, however, caused high mortalities. Gamma benzene hexachloride and parathion gave complete kill after 307 days and 15 and 95 per cent respectively after 399 days. Chlordan and the fluorine analog of DDT gave high kills up to 211 days after treatment. DDT killed no flies.

At 10 mg. per square foot all the materials caused complete or near complete kill 7 days after treatment of containers. Parathion and benzene hexachloride (koth effective at 43 days but were not so at 82 days.

LITERATURE CITED

Srivastava, A. S., and H. F. Wilson. 1947. Benzene hexachloride as a fumigant and a contact insecticide. JOUR. ECON. ENT. 40(4): 569–71.

SIZE OF SCREENS FOR ORIENTAL FRUIT MOTH BAIT JARS

The writer operated four series of bait jars in four peach orchards for catching Oriental fruit moths during the season of 1948. Each station consisted of two wide mouthed quart jars suspended in a peach tree. The bait was a solution of 1 pound of No. 8 brown sugar to each gallon of water with 2 ml. of the standard mixture of turpenyl acetate scent in each gallon. The standard scent was a mixture of 97 ml. of turpenyl acetate and 3 ml. of modified sorbitan monolaurate.[1] The solution was replaced every two weeks, alternating between the two jars at each station.

Most of the jars were covered with one quarter inch mesh wire hardware cloth, which is considered the standard size mesh to keep out of the jars as many of the larger insects as possible. Since a slightly smaller mesh would keep out many more insects, especially large flies, both jars of one station in each orchard were screened with hardware cloth of six meshes to the inch. The stations were so set up that the comparisons could not properly be checked for significant differences between the two mesh sizes. As the season advanced it was observed that the moth catches in the jars screened with the six mesh to the inch hardware cloth were decidedly smaller than in the quarter inch mesh. At times practically no moths would be taken in the smaller mesh while substantial catches would be found in the larger mesh. While this was not a carefully checked comparison and was for one season only, the writer is convinced that meshes smaller than one quarter inch will substantially reduce the catch of Oriental fruit moth in the standard bait jars.

RALPH G. PALMER, *Rochester, N. Y.*

[1] *Tween 20.*

Effectiveness of Repellents Applied to Clothing for Protection Against Salt-Marsh Mosquitoes[1]

CARROLL N. SMITH and DOUGLASS BURNETT, JR.,[2] *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Granett & Haynes (1945), Linduska & Morton (1947),[3] and Travis & Morton (1946) demonstrated that some mosquito repellents remained effective for many days when applied to clothing, and for only a few hours when applied to skin. Several thousand compounds[4] have been tested for repellency to mosquitoes at the Orlando, Fla., laboratory of the Bureau of Entomology and Plant Quarantine. Recent investigations have been concerned with the selection of repellent materials suitable for application to clothing rather than to skin. A treatment was desired that would prevent mosquito bites through the clothing after a considerable period of storage, after several days of wear, or after wetting in water.

Approximately 3400 compounds were given preliminary screening tests in the laboratory against the yellow-fever mosquito, *Aëdes aegypti* (L.). Solutions of the compounds were applied to cotton stockings, which were drawn over the forearm and exposed for short periods in cages containing the mosquitoes. Some of these compounds gave complete protection for several months and about 900 met the minimum requirements adopted for the screening tests, *viz.* less than 5 bites during a 1-minute exposure for at least 10 days after treatment. From this group 375 compounds were available in sufficient quantity for testing in the field against salt-marsh mosquitoes. The results of these tests are reported in this paper.

METHODS.—Field tests were conducted in areas infested with salt-marsh mosquitoes. The predominant species was *Aëdes taeniorhynchus* (Wied.), but at times *A. sollicitans* (Walk.) was also numerous. The repellents were applied to stockings, as the mosquitoes bite more readily through stockings than through shirts or trousers, and a subject could test two treated stockings simultaneously. The stockings were impregnated with acetone solutions of the compounds at the rate of 3 grams of repellent per square foot of cloth. They were tested the day after treatment and at about weekly intervals thereafter. Between tests the stockings were hung on lines in a ventilated shed. At each test each stocking was worn in succession by three men for 5 minutes each. If the average number of bites was as high as 1 per minute, the treatment was considered ineffective and was dropped from testing.

Repellents that were effective for 21 or more days were also tested at a rate of 0.75 gram per square foot of cloth. Repellents that were effective for 14 days at this reduced dosage, and those that were unusually effective at the heavier dosage, were subjected to extended wear and to rinsing. For the extended-wear tests the stockings that were treated at a rate of 0.75 gram per square foot were worn for 30 hours before testing and 6 hours between tests.

Untreated stockings were worn at intervals during the testing to determine the normal biting rate. In addition, whenever the abundance or avidity of the mosquitoes appeared to be declining, additional exposures with untreated stockings were made. If the biting rate was too low, the testing was moved to a more favorable locality or discontinued for the day. The biting rates during the testing periods ranged from 12 to more than 100 per minute. During July, August, and early September 1947 tests were conducted near New Smyrna, Fla., and later in the season on the Florida Keys.

RESULTS.—Fifty-one of the 375 compounds were eliminated at the time of the first test because of staining or irritation to the skin. Fifty-five were ineffective the day after treatment, 31 were effective for 1 day only, 69 for 2 to

[1] This work was conducted under a transfer of funds, from the Office of the Surgeon General, Department of the Army, and, in part, from the Bureau of Medicine and Surgery, Department of the Navy, to the Bureau of Entomology and Plant Quarantine.

[2] The authors wish to acknowledge the assistance of W. V. King, in charge of the Orlando, Fla., laboratory of this Bureau, and of B. V. Travis, in planning the tests; of Nelson Smith, Paul Schacht, and Lyda Roberson in executing the work; and of members of the Chemistry Section for preparing the repellents for testing.

[3] Also unpublished report by J. P. Linduska, F. A. Morton, and H. A. Jones, 1945.

[4] The compounds that formed the basis for this study were obtained from commercial companies, from chemists operating in various university laboratories under contracts with the Office of Scientific Research and Development, and from the Division of Insecticide Investigations of the Bureau of Entomology and Plant Quarantine.

7 days, 47 for 8 to 14 days, 30 for 15 to 21 days, and 92 for more than 21 days.

Fifty-four of the repellents that were ineffective the day after treatment are given below. The name of another has not been released by the manufacturer.

Acetic acid, resorcinol diester
Acetic acid, terpin diester
Acetoacetic acid, ethyl ester, glyceryl acetal
p-Aminodiphenyl
alpha-*n*-Amylcinnamaldehyde
Benzene, *m*-diallyloxy-
Benzoic acid
Benzoic acid, ethylene glycol monoester
3-Bromo-4-hydroxydiphenyl
Butanol 2-nitro-2-ethyl-1,3-propanediol acetal
n-Butyric acid, 3-phenylpropyl ester
Capric acid, diethylene glycol diester
Crotonaldehyde 2-nitro-2-ethyl-1,3-propanediol acetal
Crotonaldehyde 2-nitro-2-methyl-1,3-propanediol acetal
alpha-Cyanoacetic acid, cyclohexyl ester
o-Cyclohexylphenol
Cyclohexyl phenyl ketone
Dehydroacetic acid
Desoxybenzoin
2-(2,4-Dichlorophenoxy)ethanol
3,5-Diethoxyhexanol
5,5′-Diethyl-4,4′-dipropyl-2,2′-bi-*m*-dioxane
2,2-Dimethyl-5-phenyl-1,3-dioxolan-4-one
N,N-Dimethylsuccinamic acid, propyl ester
m-Dinitrobenzene
N,N-Di-iso-propylglutaramic acid, propyl ester
Elemol
Ethoximinomalonic acid, diethyl ester
Formyl diphenylamine
Glycerol *n*-butyl ether
Hexahydrophthalic acid, diethyl ester (cis)
1,2-Hexanediol
alpha-Hydroxy-iso-butyric acid, cresylglyceryl diester
beta-Hydroxyethyldodecylamine
beta-Hydroxy-beta-tetrahydrofurlypropionic acid, ethyl ester
2-Ketocyclohexylglyoxalic acid, ethyl ester
Lactic acid, 82%
Lauric acid, propylene glycol monoester
Levulinic acid, tetrahydrofurfuryl ester
Maleic acid, di-*n*-butyl ester
2-(*p*-Methoxyphenyl)ethanol
4-Methoxyvalerophenone
Methyl-3-butenylmalonic acid, diethyl ester
Myristyl morpholide
m-Nitroacetophenone
Phenoxyacetic acid
beta-Phenoxy-beta′-hydroxydiethyl ether
Phthalic acid, diethyl ester
Phthalic acid, di-iso-propyl ester
Phthalic anhydride
alpha-Propionoxypropionic acid
Pyridine, ethylenedi-, mercapto-
Sorbic acid, *n*-propyl ester
Tricarballylic acid, triethyl ester

The following 31 repellents were effective for 1 day only:

Acetic acid, alpha-methylbenzyl ethylene glycol ether ester
Acrylic acid, 2-methyl-2-nitropropyl ester
Adipic acid, diethyl ester
4-tert-Amylcyclohexanol
Anthranilic acid, methyl ester
alpha-Benzoylbutyronitrile
Benzylmorpholine
Butyric acid, 2-methyl-1,3-trimethylene diester
Caproin (or 6-Hydroxy-7-dodecanone)
2-Chloro-6-nitrotoluene
2-(2-Chlorophenoxy)ethanol
1,3-Cyclohexanediol (mixture of cis and trans)
Cyclohexyl dipropylene glycol monoether
3,4-Dichloroacetophenone
1-(2,4-Dimethylphenyl)-3-methyl-2-butanol
2,5-Endomethylene-6-methylhexahydrobenzyl diethylene glycol monoether
3-Ethoxy-4-hydroxybenzaldehyde
Furylacrylic acid, ethylene glycol ethyl ether ester
Geraniol (2nd fraction, Java citronella oil)
Lauric acid, sorbitol ester
o-Methoxybenzoic acid, methyl ester
beta-Methoxypropionic acid, 2-ethoxyethyl ester
alpha-Methylepoxycyclohexylideneacetic acid, allyl ester
Methyl "heelate" (residue from adipic acid manufacture)
Oil of bay
Oil of citronella
Phenylethyl alcohol
Plasticizer 35 (the dimethylamide of a by-product acid closely related to stearic acid)
N-*n*-Propyl-1,2,3,6-tetrahydrophthalimide
Wood distillate (66 fraction), 2-hydroxyethyl ether
Wood distillate (68 fraction), 2-hydroxyethyl ether

Sixty-eight of the 69 repellents effective for 2 to 7 days are given below. The name of the other has not been released by the manufacturer.

Acetic acid, 2-phenoxyethyl ester
1-Acetoxy-2-propanone oxime
Acrylic acid, beta-(beta-*n*-butoxyethoxy)ethyl ester
Alcohol byproduct from hydrogenation of methyl 2-naphthyl ketone
Allylaniline
N-(*n*-Amyl)succinimide
p-Anisidine
Benzaldioxime
Benzoylformic acid, ethyl ester
Bicyclo-(2,2,1)heptene-2,3-dicarboxylic acid, diethyl ester
cis-Bicyclo-(2,2,1)heptene-2,3-dicarboxylic acid, dimethyl ester
N-Butyl-*N*-(2-butyroxyethyl)butyramide
Caproic acid, 1,2-propanediol monoester
Carbonic acid, ethyl *p*-bromophenyl ester
alpha-Chloropropionic acid, tetrahydrofurfuryl ester
Cinnamic acid, iso-butyl ester
Cinnamic acid, *n*-propyl ester
alpha-Cyanobutyric acid, cyclohexyl ester
alpha-Cyanopropionic acid, *m*-methylcyclohexyl ester
Cyclohexan-1-ol-1-carboxylic acid, cyclopentyl ester
2-Cyclohexylcyclohexanol
Cyclohexyl diethylene glycol monoether
beta-Decalol
4,6-Dibromo-*o*-cresol
N,N-Di-iso-butylacetoacetamide
trans-1,2-Dicarbomethoxy bicyclo-(2,2,1)-heptene-5
N,N-Diethylfuroamide
2,5-Dimethylbenzyl cyclohexyl ether

3,4-Dimethyl-2,4-hexanediol
N,N-Di-iso-propylsuccinamic acid, sec-butyl ester
2-Ethyl-1,3-hexanediol
2-Ethyl-2-methyl-5-phenyl-1,3-dioxolane-4-one
5-Ethylnonanol-4-one-2
alpha-Ethyl-beta-phenylglycidic acid, ethyl ester
5-Ethyl-4-(2-propenyl)nonen-1-ol-4
Formic acid, cinnamyl ester
Furfurylideneacetic acid, allyl ester
Furoic acid, cyclohexyl ester
Furylacrylic acid, iso-amyl ester
1-Furylhexene-1-one-3
Hexahydroisothymol
Hexahydro-2-(*p*-methoxyphenyl)-1,3-benzodioxole
Hexahydrophthalic acid, dimethyl ester
o-n-Hexyloxybenzyl alcohol
alpha-Hydroxy-iso-butyric acid, phenylpropyl ester
1-Hydroxycyclohexylacetic acid, *n*-butyl ester
Lactic acid, beta-chloroallyl ester
N-Lactylpiperidine
dl-Malic acid, di-iso-propyl ester
Mandelic acid, ethyl ester
Mandelic acid, methyl ester
1-(4-Methoxyphenyl)-1-propanol
Methylcinnamyl alcohol
alpha-Methyl-beta-phenylglycidic acid, ethyl ester
4-Morpholineacetic acid, butyl ester
beta-Oxoglutaric acid, dipropyl ester (impure)
Phenylacetic acid, beta-chloroallyl ester
Phenyl ethylene glycol monoether
beta-Phenylethylphenol
beta-Phenyl-beta-hydroxybutyric acid, ethyl ester
Phthalic acid, dimethyl ester
Pinene, ethylene glycol monoether (*DHS Activator*)
Pinene ethylene glycol monoether, fraction boiling 267° C.
Piperonal (Heliotropine)
p-n-Propoxybenzaldehyde)
2-iso-Propyl-5-ethyl-5-nitro-*m*-dioxane
Succinic acid, di-iso-butyl ester
Tartaric acid, dibutyl ester

The 47 repellents effective for 8 to 14 days were the following:

Acetic acid, 2-benzyloxyethyl ester
Acetoacetic acid, benzyl ester
Acrylic acid, *p*-methoxybenzyl ester
Acrylic acid, beta-phenoxyethyl ester
Allyl beta-benzyloxyethyl ether
N-Allyl-1,2,3,6-tetrahydrophthalimide
o-iso-Amyloxybenzaldehyde
o-sec-Butoxybenzaldehyde
o-sec-Butoxybenzyl alcohol
N-(*n*-Butyl)acetanilide
N-sec-Butyl phthalimide
2-Chloro-5-hydroxytoluene
Cinnamic acid, allyl ester
Cinnamic acid, ethyl ester
Crotonic acid, cyclohexyl ester
1-(Cyclohexane-2-one)butanol
N,N-Diamylacetamide
Dicarboethoxyurethane
alpha,alpha-Dichlorobutyramide
3,4-Diethoxybenzaldehyde
N,N-Diethylacetoacetamide
2,6-Dimethylquinoline
N-Ethyl-*N*-phenylacetamide
N-Ethyl formanilide
alpha-Ethyl-beta-hydroxy-beta-tetrahydrofurylpropionic-acid
2-(*x*-Ethylphenyl)ethanol
Formic acid, 1,6-hexanediol diester
Geraniol (last fraction, Java citronella oil)
Glycerol-alpha,gamma-di-iso-amyl ether
2,4-Heptanediol
Hexahydrophthalic acid, diethyl ester
alpha-Hydroxy-iso-butyric acid, 2-phenylethyl ester
Lactic acid, beta-butoxyethyl ester
4-*p*-Methoxyphenyl-2-butanol
Methylphenylaminoacetonitrile
alpha-Methyl-beta-phenylglycidic acid, allyl ester
alpha-Methyl-beta-phenylglycidic acid, methallyl ester
Phenoxyacetic acid, methyl ester
1-Phenyl-2-propoxyethanol
1-Propyl-2-methyl-5-oxo-2-pyrroline-3-carboxylic acid, ethyl ester
Pyran, 2,2′-ethylenedioxybis[tetrahydro-
beta-(2-Pyridyl)acrylic acid, ethyl ester
8-Quinolinol
alpha-Tetralol
beta-*o*-Tolylethanol
n-Valeraldehyde glyceryl acetal
Wood tar distillate, soluble (S-101-B-74)

The 30 repellents effective for 15 to 21 days were as follows:

Acetic acid, 2,2′-thiodiethanol diester
2-Acetoxypropionic acid, tetrahydrofurfuryl ester
Anisic acid, *n*-propyl ester
Anthranilic acid, *sec*-butyl ester
Benzoic acid, acetonyl ester
Bicyclo-(2,2,1)heptane-2,3-dicarboxylic acid, diethyl ester
p-Butoxybenzaldehyde
alpha-Chloroacetic acid, tetrahydrofurfuryl ester
Chlorothymol
Cinnamaldehyde iso-amyl acetal
Cyclohexane-2-ol-1-carboxylic acid, *n*-butyl ester
Cyclohexylcyanoacetic acid, ethyl ester
alpha,alpha-Diethoxysuccinic acid, diethyl ester
N,N-Diethylsuccinamic acid, iso-propyl ester
Diphenylmethane
Enanthic acid, glycol monoester
Enanthic acid, 1,2-propanediol monoester
Ephedrine
2-Ethylhexyl dipropylene glycol monoether
N-Ethyl-propion-*o*-toluidide
2-Hydroxycyclohexylcarboxylic acid, iso-amyl ester
alpha-Methyl-beta-hydroxy-beta-phenylpropionic acid, ethyl ester
Methyl phenyl acetaldehyde oxime
alpha-Methyl-beta-phenylglycidic acid, propyl ester
2,4-Octanediol
2-Phenylcyclohexanol
2-(2-Phenylcyclohexoxy)ethanol
p-iso-Propoxyacetophenone
N-iso-Propylacetanilide
Salicylic acid

Of the 92 repellents effective for at least 21 days, 79 were available in sufficient quantity for use in additional treatments. When these repellents were tested at one-fourth the original dosage, 48 were effective for more than 14 days. Five were not suitable for testing by extended wear because of irritation to the skin, odor, or probable toxicity, but the remaining 43 and an additional 14 com-

Table 1.—Duration of repellency of compounds that were effective for at least 21 days at a dosage of 3 grams per square foot. Plus signs indicate records were terminated while the material was still effective.

Repellent	Field Tests: Aging Without Wearing, 3 Grams	Field Tests: Aging Without Wearing, 0.75 Gram	Field Tests: Wearing, 0.75 Gram	Laboratory Tests, 3 Grams
	Days	*Days*	*Hours*	*Days*
Compounds that appear safe for use on clothing and were effective after 36 hours of wear				
Butyric acid, 1,3-cyclohexanediol monoester	51	16	48+	44
N-Cyclohexyl-beta-butoxyethoxyacetamide	123+	19	72+	451
N,N-Diethylsuccinamic acid, *n*-propyl ester	41	21	36	38
N,N-Di-iso-propylglutaramic acid, ethyl ester	85	0	42	39
2-Ethyl-2-butyl-1,3-propanediol	94	53+	48	196
2-Ethylhexyl diethylene glycol monoether	57	43	54	29
Mandelic acid, iso-butyl ester	32+	28	42	76
Mandelic acid, *n*-hexyl ester	37	33	42	154
Mesityl oxide oxalic acid, *n*-butyl ester (*Indalone*)	38	29	48	161
beta-Methyl-beta-phenylglycidic acid, 2-ethoxyethyl ester	37	43	48+	179
N-(Mixed monoamyl)imide of 3,6-endomethylene 4-cyclohexene-1,2-dicarboxylic acid	68+	70+	48	230
4-Morpholineacetic acid, isobornyl ester	93	43	42	127
Nicotyrine	43	0	36	17
1,2-Octanediol	43	24	48+	30
beta-Phenyl-beta-hydroxypropionic acid, ethyl ester	22	42	36	36
N-*n*-Propyl-*N*-phenylacetamide	53	27	36	40+
2,5,7-Trimethyl-3-octynediol-2,5	45	0	48+	35
Undecylenic acid	51	50+	48+	19
Compounds that appear unsafe for use on clothing, or that were not effective after 36 hours of wear				
Acetophenone glycerol	45	0	—	27
N-iso-Amylacetanilide	22	28	36	20
N-Amylbutoxyacetamide (*Indimide A*)	45	32	60	16
Benzoic acid, 1,3-propanediol monoester	32	0	—	152
2-Benzoxycyclohexanol	57	—[1]	—	122
Benzyl trimethylene glycol monoether	35	—[1]	—	45
Bicyclo-(2,2,1)heptene-2,3-dicarboxylic acid, methyl propyl ester	35	44	30	88
p-sec-Butoxybenzyl alcohol	23	0	—	38
N-*n*-Butylhexahydrophthalimide	49	30	0	39
p-tert-Butylphenol	29	7	—	22+
N-Butyl-1,2,3,6-tetrahydrophthalimide	51	6+	30	32
alpha-Butyroxyacetophenone	37	—[1]	—	222
Caproic acid, diethylene glycol monoester	37	7	—	120
n-Caprylic acid	23	19	42	20
2-(2-Carbocyclohexoxyethyl)-2-methyl-1,3-dioxolane	42	30	0	90
N-beta-Chloroethyltrichloro-acetamide[2]	45+	44	0	111
4-Chloro-3,5-xylenol	45	36	0	111
Cinnamyl alcohol	24	10	—	18
Coumarin	61	23	0	28+
2-Cyclohexanecaproic acid	30	—[1]	—	29
N-Cyclohexylbutoxyacetamide (*Indimide*)	55	76+	48+	98
Decanediol-2,4	45	44+	48+	44
N,N-Di-iso-amylacetamide	30	12	—	30
Di-*n*-butyl sulfone	23	1	—	27
N,N-Diethylglutaramic acid, methyl ester	43	0	—	15
2-(*x,x*-Diethylphenoxy)ethanol[2]	37	2	—	192
N,N-Diethylsuccinamic acid, ethyl ester	23	43	0	32
N,N-Diethylundecylenamide[2]	94	29	48+	212
2,2-Dimethylnonanediol-1,3	43	—[1]	—	201
5,5-Dimethyl tetrahydro butyl coumanate	24	5	—	147
N,N-Di-iso-propyladipamic acid, methyl ester	149+	0	—	11
N,N-Di-iso-propylsuccinamic acid, iso-propyl ester	51	—[1]	—	31
5-Ethyl-4,6-decanediol	37	—[1]	—	112
5-Ethyl-2,4-heptanediol	42	0	30	17
2-Ethylhexyl glyceryl ether	65	77+	0	275
6-Ethyl-2-methyl-4-oxo-2-cyclohexene-1-carboxylic acid, ethyl ester	24	44	48+	117
5-Ethylnonanediol-2,4	145	—[1]	—	211
Fencholic acid	30	—[1]	—	36

Table 1—(continued)

REPELLENT	FIELD TESTS			LABORATORY TESTS
	Aging Without Wearing		Wearing	
	3 Grams	0.75 Gram	0.75 Gram	3 Grams
Furoylacetic acid, ethyl ester	23+	22	30	18
n-Hexyl diethylene glycol monoether	26	30	42	25
o-Hydroxybiphenyl	30+	0	—	15+
1-Hydroxycyclohexanecarboxylic acid, 2-butoxyethyl ester	43	45+	0	66
1-Hydroxycyclopentanecarboxylic acid, 2-butoxyethyl ester	49	1	0	35
2-Imidazolidone, 1,3-bis(butoxymethyl)-	43	—[1]	—	167+
Lactic acid, diethylene glycol butyl ether ester	30	36+	0	32
Levulinic acid, benzyl ester	37	—[1]	—	121
dl-Malic acid, di-*n*-butyl ester	57	0	30	11
Mesityl oxide oxalic acid, ethyl ester	57	7	0	15+
Methyl amyl alpha-glyceryl ether	51	14	30	35+
2-Methyl-4-oxo-6-propyl-2-cyclohexene-1-carboxylic acid, ethyl ester	35	42+	0	88
beta-Methyl-beta-phenylglycidic acid, allyl ester	44+	1	0	13
beta-Naphthol	143+	42	—[3]	23+
m-Nitrobenzaldehyde	30	43	36	47
2,3-Octanediol	45	2	48+	13
alpha-*n*-Octylcinnamaldehyde	24	—[1]	—	145
Pentachlorophenol[2]	59	84+	Toxic	57
Phenoxyacetic acid, 2-ethoxyethyl ester	37	1	—	158
3-Phenylbutanol-1	30	—[1]	—	45
1-Phenylcyclohexanol	49	0	—	47
beta-Phenylglycidic acid, propyl ester	70	0	—	49
beta-Phenyl-beta-hydroxypropionic acid, methyl ester	22	32	30	17
beta-Phenyl-beta-hydroxypropionic acid, iso-propyl ester	43	0	—	45
Phosphoric acid, tributyl ester	81	76+	42	132
Propiophenone oxime	43	1	0	28+
p-*n*-Propoxybenzyl alcohol	35	0	—	83
Tetrachlorophenol[2]	62	70	—[4]	103
2,3,4,6-Tetrachlorophenol[2]	94	77+	60	56
1,2,3,4-Tetrahydro-2-naphthol	57	5	—	35
2,4,7,9-Tetramethyl-5-decynediol-4,7	76	30	0	22+
Thiocyanic acid, 2-(2-butoxy-ethoxy)ethyl ester (*Lethane 384*)	30	6	—	17
2-(*m*-Tolyl)cyclohexanol (trans-)	50	27	0	37
Undecalactone	55	27	—[5]	53
Wood tar distillate, soluble (S-101-B-65)	23	22	—[3]	13
Wood tar distillate, soluble (S-101-B-78)	53	20	0	22

[1] Insufficient quantity available for testing.
[2] Rated unsafe for use on clothing at 2 grams per square foot in tests by the U. S. Food and Drug Administration.
[3] Not tested by continuous wear because of irritation to the skin.
[4] Not tested by continuous wear because of toxicity.
[5] Not tested by continuous wear because of odor.

pounds that had given complete protection for 40 days at the full dosage were subjected to wearing tests. Eighteen repellents were ineffective and 8 were effective after 30 hours of wear, 7 were effective after 36 hours, 7 after 42 hours, and 17 after 48 hours or more. The results with the 92 repellents are presented in table 1. The results obtained in the preliminary laboratory tests with these materials are included for comparison. CAUTION: Additional toxicological studies will be required before unrestricted use of most of these compounds can be recommended.

Repellents that gave particularly good records included *N*-cyclohexyl-beta-butoxyethoxyacetamide; 2-ethyl-2-butyl-1,3-propanediol; 2-ethylhexyl diethylene glycol monoether; *N*-(mixed monoamyl)-imide of 3,6-endomethylene-4-cyclohexene-1,2-dicarboxylic acid; iso-bornyl ester of 4-morpholineacetic acid; and undecylenic acid. Among the more effective repellents, three were of special interest because they are also effective when applied to the skin namely, *n*-propyl ester of *N*,*N*-diethylsuccinamic acid; *n*-butyl ester of mesityl oxide oxalic acid (*Indalone*); and ethyl ester of beta-phenyl-beta-hydroxy propionic acid.

SUMMARY.—In the course of a study of

mosquito repellents in Florida 375 compounds that had shown promise in the laboratory for use to impregnate clothing were tested in the field against the salt-marsh mosquitoes *Aëdes taeniorhynchus* (Wied.) and *A. sollicitans* (Walk.). Of these compounds 92 were effective for more than 21 days of aging, and 31 were effective after at least 36 hours of wear. The outstanding repellents included *N*-cyclohexyl-beta-butoxyethoxyacetamide (effective after 451 days of aging in the laboratory and more than 123 days of aging and 72 hours of wear in the field); 2-ethyl-2-butyl-1,3-propanediol; 2-ethylhexyl diethylene glycol monoether; *N*-(mixed monoamyl)imide of 3,6-endomethylene-4-cyclohexene-1,2-dicarboxylic acid; iso-bornyl ester of 4-morpholineacetic acid; and undecylenic acid. The *n*-propyl ester of *N,N*-diethylsuccinamic acid, *n*-butyl ester of mesityl oxide oxalic acid (*Indalone*), and the ethyl ester of beta-phenyl-beta-hydroxypropionic acid were among the more effective repellents, and are of special interest because they are also effective when applied to the skin.

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Diagnosis and Control of Mange in Dairy Cattle[1]

H. H. SCHWARDT, *Cornell University, Ithaca, New York*

Cattle mange caused by *Sarcoptes scabiei caprae*, and *Chorioptes bovis* apparently is on the increase in northeastern United States. As recently as 1943 mange was uncommon in New York but during the past 5 years a steadily increasing number of cases have been reported. During the winter of 1947–48 New York state veterinarians under the direction of Doctor Ivan G. Howe surveyed a considerable area in various parts of the state and diagnosed mange in 720 herds aggregating 21,000 dairy cattle. With one known exception the beef herds of the state have escaped infestation. In several herds where the condition was not diagnosed in an early stage cattle have died as the result of generalized mange. In many others cattle have lost condition and milk production fallen far below normal. This paper describes a new method for positive diagnosis of mange and reports the results of 3 years of control work.

Cattle mange is easily confused with a variety of other skin conditions notably those caused by X-disease, Stephanofilariasis, and in some cases lice. Correct diagnosis during the early stages of infestation is important if control measures are to be applied in time to prevent serious losses.

Definite diagnosis is made by microscopic examination of deep skin scrapings, and in doubtful cases special preparation of material from the scrapings is advisable. The method to be described was developed by Doctor Donald W. Baker[1] and has often given positive diagnosis in early cases when microscopic examination alone had failed to show the presence of mites.

Scrapings are made at the edges rather than at the center of apparently active lesions. They must be deep enough to draw blood if the sub-dermal Sarcoptic mites are to be found. Immediate microscopic examination of the scraping may reveal the mites if they are numerous. A wide field binocular microscope should be used. If none are found during this superficial examination the scraping must be treated to concentrate the few mites possibly present. Material from the scraping is placed in 30 to 50 cc. of 10 per cent KOH or NaOH, heated nearly to the boiling point, and allowed to simmer for several minutes. This destroys hair, particles of skin, and other detritus but

[1] The work reported herein was largely financed by a grant in aid from the Swift Company, Chicago, Illinois.

[1] Donald W. Baker is Professor of Veterinary Parasitology at the New York State College of Veterinary Medicine at Cornell University. His cooperation and active assistance during the course of this work is gratefully acknowledged.

leaves the exoskeletons of the mites intact The liquid containing the mites is then centrifuged and most of the liquid poured off. The remaining sediment is then washed several times, the sediment being brought down by centrifuging after each addition of water. After the final washing the water is poured off and the tube half filled with a sugar solution made by dissolving a pound of sugar in a pint of water. The sediment is then completely stirred so that it is suspended in the solution. The tube is then completely filled with solution so that a cover slip placed over its opening makes complete contact with the solution. With the cover slip in place the solution is centrifuged. Any mites present are brought to the surface and adhere to the under side of the cover slip which is then placed on a slide for examination. This technique frequently shows the presence of mites when none can be found by examination of the untreated scraping.

Chorioptic mites usually can be found by examining untreated scrapings but the digesting and centrifuging process sometimes assists in finding them also. The same can be said of Psoroptic mites. Demodectic mites of cattle occur in pea sized nodular swellings under the skin and can be identified by examination of the waxy material that fills the nodules and consists mostly of mites. The mites are more easily seen if the specimen to be examined is spread and diluted on the slide with a drop of ether or chloroform.

In the north nearly all serious cases of mange occur during the colder part of the year. The season of heaviest infestation in New York is from November to April inclusive. Herds with advanced cases appear to recover during the summer while on pasture but mange usually recurs after the herd is stabled for the winter. When mangy animals are first released from their stanchions and turned out to pasture in the spring they scratch and lick themselves until large raw areas appear on the skin. This may occur even in herds that appeared to have little or no infestation while still in winter quarters

Dipping northeastern dairy cattle for mange control is impracticable for several reasons. The average number of animals in New York herds is 25. This is too small an enterprise to support the construction of a concrete vat, and the cost of filling such a vat would be high in relation to the number of animals to be treated. Community vats would require driving some herds long distances for treatment—something few dairymen would care to do. It is probable that the rough treatment usually required to get cattle through a vat would do the large dairy breeds more harm than normal cases of mange. Northern cattle are wintered in relatively warm barns. Taking them out of this environment for dipping during the cold weather usually prevailing in mange season probably would be unsafe.

Spraying with high presure equipment is the alternative to dipping and has given excellent control of mange during three seasons of work in New York. The type of sprayer found most practical for this work has a tank capacity of 150 gallons, a pump capacity of 7 to 10 gallons per minute, and develops about 400 pounds of pressure. Such a rig will serve two hose lines and one filling of the tank will spray the largest herds commonly found on New York farms. Larger tank and pump capacities are neither necessary nor desirable since they will not speed up the work and entail extra weight to be hauled over country roads in bad weather. A convenient refinement for the livestock sprayer is a hose reel with flexible center and swivel connection to the pump outlet. The best type of spray rod testedconsisted of a 5-foot piece of quarter inch galvanized pipe with two nozzles set 6 inches apart and at right angles to the pipe. A pistol-grip cut-off was used and a swivel inserted between cut-off and hose.

All animals used in the tests were sprayed while confined in stanchions. Most of each animal was sprayed from behind and the head and neck from in front of the stanchions. It was found necessary to use at least 2 gallons of spray on each animal to insure complete coverage and thorough wetting of the hair. None of the test animals suffered ill effects from being sprayed in cold weather due probably to the fact that dairy barns usually have a temperature around 50 degrees even in severe weather.

Materials tested were lime sulphur solution, wettable sulphur, wettable sulphur and rotenone, and benzene hexachloride. Since the effectiveness of lime sulphur solution was well known only two herds totaling 27 cattle were sprayed with this material. A 1 to 15 dilution was used

and the material applied at a tank temperature of about 100 degrees. Four applications at weekly intervals were made. No mites were found immediately after the last treatment but questionable lesions still were present. Examination 8 months after treatment revealed no mites.

Wettable sulphur at a strength of 30 pounds in 100 gallons was applied to three herds totaling 95 animals, and four sprays were again applied at weekly intervals. Both Sarcoptic and Chorioptic mites were found on one animal in one herd after the third application but none were found on any of the herds in December, 8 months after treatment. A fourth herd received four applications of wettable sulphur at a dosage of 20 pounds in 100 gallons and remained free of mange 8 months after spraying.

Three herds aggregating 92 cattle were sprayed 4 times with a mixture containing 20 pounds of wettable sulphur and 1 pound of 5 per cent rotenone in 100 gallons. All were free of mange after the last application and remained so several months afterward. Two applications at the same dosage were less satisfactory as demonstrated on two herds totaling 73 animals. The rotenone was added to control lice present on some of the herds. Its possible acaricidal effects are not indicated in these tests since wettable sulphur alone was shown to be effective.

During the late winter and early spring of 1948 two dosages of benzene hexachloride were tested on a total of 448 cattle in 13 herds. The results indicate that a single application at dosages safe on dairy cattle will not always eradicate Sarcoptic or Chorioptic mange. Five herds totaling 142 animals were sprayed at a dosage of 4 pounds of 6 per cent gamma material in 100 gallons. While an immediate and considerable improvement was noted in all of these herds, three of them suffered a heavy recurrence of mange within 6 weeks. Two of them were resprayed a month after the first application using a 6-pound dosage, but were again mangy less than a year later.

Three hundred six animals in 8 herds were sprayed with 6 pounds of 6 per cent material in 100 gallons but mange also recurred in three of these herds. Several however appeared to be completely cured and the owners were highly pleased with the increases in production obtained. The above tests suggest that at least two applications will be necessary to eradicate mange when 6 pounds of 6 per cent gamma benzene hexachloride is used in 100 gallons of spray. Higher dosages on dairy cattle seem inadvisable since data from other sources indicate that at a dosage of about 0.05 per cent gamma some injury to young calves may be expected. The possibility of tainting or building up intolerable residues in milk is also a factor limiting the maximum safe dosages on dairy cattle. No complaints about benzene hexachloride taste or odor in the milk were entered by owners of treated herds or by the consumers of their milk during these tests.

Chemical analyses, based on determination of organic chlorine, showed that milk from cattle sprayed with 6 pounds of 6 per cent material contains between 2 and 3 parts per million of benzene hexachloride within a few hours after treatment.[1] This residue diminishes rapidly and none can be detected after about a week. This amount of residue however would never occur in the ultimate consumers milk unless all herds contributing to one milk plant were sprayed the same day. Such an event is statistically improbable, and practically, almost impossible. A few herds sell directly to the consumer and here the hazards would be greater though still probably insignificant since residue-bearing milk would be delivered only a few days out of the year.

[1] Since these analyses were made the methods of analysis have been further refined. It now appears that the figure of 2 to 3 parts per million is somewhat low and would be nearer 4 parts per million.

"A Century of Entomology in the Pacific Northwest" by Melville H. Hatch has recently been published by the University of Washington Press, Seattle, Wash., in 43 pages with nine full page plates of pioneer and leading entomologists. Price $1.50.

Control of *Anopheles* Mosquitoes with Coarse and Fine DDT Sprays Applied by Airplane

C. C. Deonier,[1] W. N. Sullivan,[2] Edward Nottingham,[1] and Arthur W. Lindquist[1,3]

Area control of the common malaria mosquito, *Anopheles quadrimaculatus* Say, with DDT sprays applied by airplane was investigated in 1945 by the Bureau of Entomology and Plant Quarantine in cooperation with the Army Air Forces Board. The effect of droplet size was studied by comparing the efficiency of a coarse spray and a fine spray. The fine spray was produced by an exhaust venturi on a C-47 plane and the coarse spray by a gravity-fed straight-discharge pipe on a B-25. The sprays were applied by the Army Air Forces over areas near De Land, Fla., that had been under observation for several years by personnel of the Orlando, Fla., laboratory of the Bureau and were known to have high anopheline populations.

Description of Test Areas.—Three areas west of De Land, along the St. Johns River, were chosen for these tests. At first only two adjacent areas (A and B) which were thought to be similar in over-all environmental conditions were sprayed. Later, however, a third area (C) was sprayed to prevent infiltration of adult mosquitoes into the treated areas. Each area covered approximately 1.3 square miles. Areas to the east and southeast of the B and C areas were used for checking normal adult populations. Even though these areas were across the river from the treated areas, they were inadvertently sprayed.

A Area.—The A area was chosen so that the spray would cover breeding places from the upland pine hummocks on one side of the river to the pine hummocks on the other side. Several cypress swamps, which had been logged off in years past, were covered with a second growth of hardwoods. During the rainy season, when these studies were made, all the swamp area was under water. Old oxbows and borrow pits were filled chiefly with water hyacinth. Along the southwest side of the area there were a number of marshy ponds of the shallow upland type. Mosquito resting stations were located on a farmstead as near as possible to the center of the area. A fish camp, a small farmhouse, and a drawbridge-caretaker's house in the area also provided resting stations. The environs were uninhabited, except for a farmstead 4.3 miles west of the area, the B area on the southeast, and a small dairy on the east. Those to the north and northwest were inaccessible except by boats along the river. The livestock population in this area was high at all times.

The mosquito resting stations were set up in a hollow log, a small shed by the river, two outdoor toilets, and two cow sheds.

From time to time hollow trees and stumps at various locations in the area were examined. Other possible resting stations at the farmstead were also observed, so that any shifts of the adult population might be checked.

Thirteen dipping stations for larvae were located as follows: Stations 1 and 7 in trash and flotage, 2 to 6 in water hyacinth, 8 to 10 in grass and trash, 11 in a marshy pond, and 12 and 13 in flotage of the backwaters of the St. Johns River. The conditions of growth at the dipping stations in the water hyacinth remained constant though the water level fluctuated, but at the remaining stations they varied radically during the summer, depending on the amount of rain and floodwaters.

B Area.—The B area bordered the A area on the southeast. This area was also chosen so that the treatment would cover a section extending across the river. A farmstead was located at the edge of a swamp, which surrounded it on the south, east, and northeast. There was also a large lumber camp adjacent to the farmstead. Latrines provided for each house in the lumber camp served as resting places for large numbers of mosquitoes.

A dairy farm, a poultry ranch, and a citrus farm adjoined the area on the east, and a sawmill and two fish camps on the

[1] U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine, working under a transfer of funds, recommended by the Committee on Medical Research, from the Office of Scientific Research and Development to the Bureau of Entomology and Plant Quarantine.

[2] Captain, Sn.C., U. S. Army, now with U.S.D.A.

[3] The writers appreciate the advice of E. F. Knipling, in charge of the Orlando, Fla., laboratory at the time, and of Lt. Col. J. Q. A. Daniels of the Army Air Forces.

southeast. To the south were unbroken cypress swamps, which had been or were being cut over. The environs on the west and southwest were uninhabited.

The human population in the area was high at all times, as was the livestock population, which had free range.

The mosquito resting stations were set up at the farmstead and the lumber camp, and in hollow stumps or logs. Observations were made in other locations as the mosquitoes shifted their resting places.

The breeding places in this area were more diverse than in the A area, particularly as to their suitability for breeding. Dipping stations 1 to 4 were in flotage and swampy areas, 5 to 7 in marshy borrow pits, and 8 to 10 in shallow marshy ponds. Stations 5a, 5b, and 5c were located in an open swamp, where breeding conditions were especially variable. However, during the first half of August the conditions were favorable and the number of adults produced was enormous. It was the breeding in this swamp and at stations 1, 2, and 3 that made it necessary to treat the C area.

C Area.—The C area bordered the B area on the southeast and extended about 1 mile to the river. It was largely jungle and swamp, and during flood periods was entirely under water. This area was uninhabited, but produced a large number of adult mosquitoes which infiltrated into the B area and the check areas.

EXPERIMENTAL PROCEDURE.—The spray solution containing 20 per cent of DDT (wt./vol.) was prepared by adding No. 2 fuel oil to a preparation containing 40 per cent of DDT in an oil[1] (chiefly methyl and polymethyl naphthalenes). The test areas were sprayed three times—on August 7, September 1, and October 18. The first and third applications were made at the rate of 0.3 pound of DDT (1.5 pints of spray) per acre and the second application at 0.6 pound (3 pints of spray). The applications were made simultaneously by the two planes between 7 and 8 a.m., when conditions are favorable for maximum settling of the fine particles. The droplets of the coarse spray applied from the B-25 plane had a mass median diameter of 150 microns, and those of the fine spray delivered by the C-47 were 50 to 65 microns in diameter.

The population counts of adult anophelines were made in favorable resting places on several mornings immediately before the first spraying and almost daily throughout the test period.

The dipping stations for larval counts were sampled before and after spraying to determine the effectiveness and completeness of the coverage. Dips were made once a week. Because of changes in breeding conditions, some of the dipping stations were changed from time to time.

The results against the larvae are summarized in table 1, and against the adults in table 2.

Table 1.—Comparative effectiveness against *Anopheles* larvae of coarse and fine DDT sprays applied by airplane.

Date of Application	Dosage (Pound per Acre)	Date of Count	Average Number of Larvae per Dip	
			A Area (Coarse Spray)	B Area (Fine Spray)
Pretreatment	—	Aug. 6	4.34	4.25
First	0.3	8	.01	.02
(Aug. 7)		13	.46	.83
		20	.94	2.64
		27	2.8	5.5
Second	.6	Sept. 2	0	.007
(Sept. 1)		10	0	.24
		Oct. 15	3.7	5.46
Third	.3	Oct. 21	.55	.08
(Oct. 18)		29	1.85	2.4

RESULTS OF FIRST APPLICATION.—After the first application the results against adults were confused by infiltration of adults into the B area. Since the C area was adjacent to the B area, and the larval control in the B area was almost complete, the continued presence of large numbers of unfed, newly emerged adults in the treated area (B) could only have resulted from infiltration.

The larval control after 24 hours was 99.7 per cent in each area. Control was obtained even through a rather heavy canopy with the coarse spray. The period of larval control was greater in the area treated with this spray than in that given the fine spray.

A rain on the day after spraying probbly accounts for the low kill of adult mosquitoes (Table 2) in this test as compared with the third test. Subsequent rains may have reduced the effectiveness of any residual DDT that might have been present. There was no residual action on the adults after the first 24 hours. The continued low adult population in the A area was due to the elimination of the larvae. Heavy rains retarded larval development

[1] *S/V Culicide Oil B.*

Table 2.—Comparative effectiveness against *Anopheles* adults of coarse and fine sprays applied by airplane.

Date of Application	Dosage (Pound per Acre)	Date of Count	Number of Adults in Resting Stations		
			A Area (Coarse Spray)	B Area (Fine Spray)	Check Area
First (Aug. 7)	0.3	Aug. 9	342	811	4273
		10	677	1519	4288
		11	370	2289	—
		12	258	1738	—
		13	353	1712	—
		17	484	805[1]	2650
		20	352	887[1]	—
		23	461	1576	1640
		24	847	1773	2443
		25	996	1820	2522
		26	670[2]	2341	2502
		27	785[2]	2091	—
		30	1586	1776	2275
		31	1389	1847	2432
Second (Sept. 1)	.6	Sept. 2	8	14	1327[3]
		3	21	21	556
		4	50	66	835
		5	64	55	935
		6	96	22	938
		10	109	35	1533
		13	170	59	1173
		17	276	337	372[4]
		20	817	51	1076
		24	1422	750	786
		27	1105	759	1381
		Oct. 1	2796	1086	—
		4	3989	961	1505
		8	2882	494[5]	2046
		11	6460	1575	1362
		15	4139	2772	1883
		16	5458	1587	—
		17	5458	1309	391[4]
Third (Oct. 18)	.3	Oct. 18 (7 A.M.)	6691	2044	1250
		18 (10 A.M.)	5000+	279	—
		19	114	20	140[6]
		20	29	12	183
		22	31	20	206
		25	283	101	—
		29	510	—	—

[1] Drop in count represents a shift in resting places and not a population slump.
[2] A wild cow in one of the cow sheds prevented observations in one of the leading resting stations.
[3] Light spray drifted into check area. Subsequent reduction reflects larval control in the C area.
[4] Low population reflects abnormal climatic conditions.
[5] Observations made at noon instead of morning.
[6] Area was sprayed accidentally on October 18.

during the second week after treatment, so that a significant increase in the adult population did not occur until about August 24.

RESULTS OF SECOND APPLICATION.—At this time both the A and C areas were treated with the coarse spray, the C area being sprayed to prevent infiltration of adults into the B area.

The reduction of adults in resting stations was 99 per cent in 24 hours in both the A and B areas. The adult population remained low for 2 weeks. When allowance is made for the developmental cycle of the malaria parasite, the spraying might be considered to prevent disease transmission for almost a month.

The larval control in 24 hours was 100 per cent in the A area and 99 per cent in the B area (table 1). The dosage used (0.6 pound of DDT per acre) was in excess of that known to give good larval control. After 10 days the control of larvae was still 100 per cent in the A area and 96 per cent in the B area. Since more material reached the ground with the coarse spray, and the adult population was about the same in the two areas, there is an indica-

tion that a residual effect persisted longer in the area receiving the coarse spray.

The adult population build-up was slow after this heavier DDT treatment. The population began to increase by September 13. A hurricane on September 16 flooded the breeding area and may have contributed to the temporary population slump of September 20. The C area was flooded, breeding was heavy in the flotage, and the open swamp was flooded to such a depth that there was very little emergent vegetation or protection from fish. The subsequent receding water stranded flotage, and therefore adult production was reduced. However, the open swamp areas had been freshened with the flood water and the algae had resumed growth, presenting a favorable condition for anopheline breeding. The breeding places in the A area were not so easily influenced by these weather conditions. On October 1 there was a high adult population on an upward trend, and the plots were again ready for treatment.

RESULTS OF THIRD APPLICATION.—In this test the C area was also sprayed as a precaution against infiltration. The adult control after 2 hours was over 85 per cent in the area given the fine spray but there was no appreciable reduction in that given the coarse spray. After 24 hours the control was 99 and 98 per cent in the respective areas. This delayed action in the area treated with the coarse spray showed that the reduction was due to the mosquitoes contacting the spray deposit rather than to their being hit by airborne spray droplets as they were in the B area. The high degree of adult-mosquito control in 2 hours with the fine spray indicated penetration of resting places, with almost immediate kill of adults in these places. Whether the kill obtained was due to actual penetration of the DDT into the resting places, or to the mosquitoes contacting DDT outside the resting places was not determined. However, an almost immediate effect of the spray was to force mosquitoes from their resting places out into the open.

The check area was accidentally sprayed, and as a result the adult population was reduced.

The data on larvae are erratic, because several larval stations in the A area were not treated owing to faulty airplane spraying. There was prolonged residual action in the area where coverage was obtained.

CONCLUSIONS.—It was demonstrated that small amounts of concentrated DDT spray could be applied as effectively with a streamlined discharge pipe as with the more complex exhaust equipment. However, it is apparent that, for test purposes, 0.3 and 0.6 pound per acre are overdosages, and that further tests should be conducted at lower rates of application.

An area treatment by airplane appears to be definitely practical to bring an outbreak of malaria under control. A spray interval of almost a month is indicated, when the developmental period of the malaria parasite is considered.

The fact that the mosquitoes contacted the residues from the coarse spray on the night after the treatment indicates the desirability of making tests late in the day shortly before the anophelines become active.

SUMMARY.—Experiments were conducted near De Land, Fla., to compare the efficiency of coarse and fine DDT sprays applied by airplane for the control of *Anopheles* mosquitoes. The fine spray (50 to 65 microns) was applied from an exhaust venturi on a C-47 plane, and the coarse spray (150 microns) from a gravity-fed straight-discharge pipe on a B-25. Three applications were made about a month apart, the two types of sprays being applied simultaneously. The first and third applications were made at the rate of 0.3 pound (1.5 pints of spray) and the second at 0.6 pound of DDT per acre.

The two types of sprays were equally effective against adult mosquitoes, reducing populations by 98 and 99 per cent. The fine sprays killed adults faster than the coarse sprays, but did not give so heavy a deposit. Rains apparently reduced the residual effectiveness of the treatments.

Excellent control of larvae was obtained, and in the area receiving the coarse sprays there was evidence of a residual effect.

Mosquitoes were held in check for approximately 10 to 14 days during the active breeding season.

These experiments show that coarse sprays obtained from the straight-discharge pipe give just as good control as the fine sprays produced by the more complex exhaust equipment.

Studies of Mosquito and Other Biting-Insect Problems in Alaska

B. V. Travis, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Adequate protective measures against mosquitoes and other biting insects in the arctic and subarctic regions have been needed for many years but the need has become more urgent recently with the increased military interests and the development of natural resources in these regions. In addition, the annoyance from biting insects is frequently so severe that the full recreational value of these areas is not realized.

During the summers of 1947 and 1948 a detailed study was made in Alaska to ascertain the seriousness of the insect problems and to determine the effectiveness of recently developed control methods, insecticides, and repellents in northern regions. This study was concerned primarily with problems that directly affect military forces, although the same problems are also of importance to civilian groups. The Army Committee on Insect and Rodent Control, as sponsor, designated the Bureau of Entomology and Plant Quarantine of the U. S. Department of Agriculture as the agency responsible for the administration and execution of the project. Funds were provided by the Office of the Surgeon General, Department of the Army, and the Bureau of Medicine and Surgery, Department of the Navy. The supplies and equipment were provided by the Office of the Quartermaster General, Office of the Chief of Engineers, and the Alaskan Command. Personnel for the study was assigned from the Bureau of Entomology and Plant Quarantine, Office of the Surgeon General, Office of the Quartermaster General, Quartermaster Board, Army Chemical Corps, Office of the Chief of Engineers, Fish and Wildlife Service, U. S. Public Health Service, the Division of Entomology of the Canadian Department of Agriculture, and the Alaskan Command.

The group established headquarters at Fort Richardson, Alaska, near Anchorage, and located most of the study plots along the highways and at a few points that could be reached only by air. The highway system consists of approximately 1500 miles of graveled roads connecting Anchorage, Willow, Valdez, Chitna, Slana, Nabesna, Tok, Yukon border, Fairbanks, Circle, and Livengood. The places visited by air were Adak, Nome, Umiat, Naknek, Point Barrow, McKinley Park, and Clear. For additional observations points between Anchorage and Fairbanks and between Anchorage and Whittier were reached by train. Pigot Point was visited from Whittier by boat.

In both years the staff consisted of 21 technical workers, representing the fields of entomology, botany, climatology, insect ecology, aquatic biology, biophysics, supply, and equipment engineering. In addition, the Army in Alaska furnished four part-time field aids in 1947 and 19 in 1948. Besides the study of control methods, qualified specialists were assigned to gather supporting information on such phases of the work as biology and taxonomy of insects, weather, vegetation, aquatic biology, and equipment, which is necessary for a full understanding and operation of such a project.

The investigations were divided into eight main projects with a specialist assigned to each as the responsible leader.[1]

The various phases of the work will be reported by the different workers as the data are analyzed. This paper includes only a preliminary summary, together with some of the representative data.

Control Studies.—Extensive studies were made with DDT and several other insecticides for the control of mosquito and black fly (Simuliidae) larvae and adults and of *Culicoides* adults in several sections of Alaska. The insecticides were first applied on small plots with hand

[1] The projects with their leaders were as follows: (1) Biology and taxonomy, Alan Stone, Bureau of Entomology and Plant Quarantine, and Dale Jenkins, Chemical Corps, 1947; R. I. Sailer, Bureau of Entomology and Plant Quarantine, and Kathryn Sommerman, Office of the Surgeon General, 1948. (2) Control of larval insects, C. M. Gjullin, Bureau of Entlmology and Plant Quarantine, 1947 and 1948. (3) Control of adult insects, C. S. Wilson, Bureau of Entomology and Plant Quarantine, 1947; F. S. Blanton, Office of the Surgeon General, 1948. (4) Aquatic biology, O. B. Cope, Fish and Wildlife Service, 1947; D. A. Sleeper, Bureau of Entomology and Plant Quarantine, 1948. (5) Repellents and protective clothing, K. H. Applewhite, Office of the Quartermaster General, and Carroll N. Smith, Bureau of Entomology and Plant Quarantine, 1948. (6) Vegetation Studies, Father Hugh O'Neill, Office of the Quartermaster General, 1947, and Father Ernest LePage, Office of the Quartermaster General, 1948. (7) Climatic studies, R. D. Campbell, Office of the Quartermaster General, 1947; R. L. Pratt, Office of the Quartermaster General, 1948. (8) Equipment, J. H. Convey and Lee Norris, Chemical Corps, 1947; C. N. Husman, Bureau of Entomology and Plant Quarantine, 1948.

equipment or light aircraft to evaluate the different chemicals in various formulations and at several dosages against the various stages and species of pests. The most effective treatments on the small plots were then applied by large aircraft[1] on areas of 1 to 30 square miles to determine their effectiveness and practicability on a scale commensurate with the needs under arctic conditions.

Mosquito Larvae.—Two methods for the control of mosquito larvae were given trials—prehatching treatments and conventional larvicide applications.

One series of the prehatching treatments was made in August 1947 before freezing occurred, and the other in the spring of 1948 while breeding areas were still covered with snow and ice. In the fall DDT, as an emulsion, fuel-oil solution, larvicide dust, and wettable-powder suspension were applied at rates ranging from 0.1 to 2 pounds of DDT per acre. Chlordan, chlorinated camphene, and technical benzene hexachloride (12 per cent gamma) were applied in fuel-oil solutions at 1 pound per acre. Benzene hexachloride was also applied as a wettable powder (6 per cent gamma) at the rate of 0.5 pound of gamma per acre. In the spring DDT was applied as an emulsion, solution, dust, and wettable powder suspension at 0.5 and 0.1 pound of DDT per acre, and as a fuel-oil solution and a dust at 0.05- and 0.01-pound dosages. Chlordan, chlorinated camphene, dichlorodiphenyldichloroethane and methoxychlor (methoxy analog of DDT) were applied in fuel-oil solutions at 0.5- and 0.1-pound dosages, and parathion at 0.1 and 0.01 pound.

The prehatching treatments with DDT were highly effective under certain conditions but failed in others, an indication that this method of control may not have so wide an application in the northern regions as expected. The control was 90 per cent or higher in plots treated by hand in the fall with DDT at 2 pounds per acre in fuel-oil solution, emulsion, and wettable-powder suspension; at 0.5 pound in fuel oil and wettable-powder suspension; and at 0.1 pound as an emulsion. Similar control was obtained in airplane spray tests with fuel-oil solutions applied at 1 pound of DDT per acre. In the spring treatments only the fuel-oil solutions of DDT at the 0.1-pound dosage and dichlorodiphenyldichloroethane at the 0.5-pound dosage gave better than 90 per cent control. Methoxychlor at 0.5- and 0.1-pound dosages and parathion at 0.1- to 0.01-pound dosages failed to give a reduction of the larvae. DDT was more effective in fuel-oil solutions and emulsions than in dusts. There was no significant difference between the fall and the spring treatments, but there was a great difference in effectiveness in the various environments. In some types of breeding areas as little as 0.1 pound per acre of DDT proved effective, whereas in other types a dosage of 2 pounds per acre failed to give satisfactory control.

Small-plot larvicidal applications of various insecticides against fourth-instar *Aëdes* were made in 1947 and 1948. Most of the materials were applied as sprays in fuel-oil solution at the rate of 0.1 pound of insecticide or 2 quarts of solution per acre, but parathion was applied at 0.025 pound per acre. Other formulations of DDT and benzene hexachloride were tested for comparison. The results were as follows:

Material	Average Mortality in 48 Hours
1947	
DDT:	
Fuel-oil solution	93
Emulsion	97
Wettable powder, 50 per cent	79
Dust, 10 per cent	57
Chlordan	55
Chlorinated camphene	80
Benzene hexachloride, 12 per cent gamma:	
Fuel-oil solution	84
Wettable powder, 50 per cent	82
1948	
DDT	88
Dichlorodiphenyl di-chloroethane	84
Methoxychlor	82
Parathion	66

Larvicidal applications of 0.1 and 0.2 pound of DDT per acre with a plane[2] to 7- to 25-acre plots caused mortalities of 93 to 99 per cent and 91 to 100 per cent, respectively. In these tests, in which equal amounts of DDT were applied in 20- and 5-per cent solutions, slightly better kills were obtained with the more concentrated solution.

One plot of 30 square miles was treated with a plane[2] to control mosquito larvae, and observations were continued to de-

[1] C-47.
[2] L-5.

termine how rapidly and in what numbers mosquitoes would infiltrate into such a large area. Six square miles of this plot were treated with 0.1 pound of DDT, or 0.5 pint of 20-per cent spray per acre, and the remaining 24 square miles with twice this dosage. The 0.1- pound application caused an average larval mortality of 89 per cent, and the 0.2- pound dosage 99 per cent. The low kill with the 0.1-pound dosage was due to poor coverage on one end of the plot, where a high, bordering moraine and a tail wind of 15 m.p.h. interfered with the proper flight and spray distribution. Large numbers of adults infiltrated the treated area as soon as emergence began in surrounding untreated areas, and after a few days it was necessary to spray the area for their control. It was therefore indicated that larval control was not very effective as a protective measure on areas up to 30 square miles.

Mosquito Adults.—Heat-generated aerosols and airplane sprays were tested for their effectiveness against mosquito adults. The aerosols were applied with Besler-type equipment, as modified by the Chemical Corps, and the sprays by an airplane[1] fitted with improved equipment developed by Insect Project personnel in Alaska.

The heat-generated aerosols were tested in 1947 and were found to have a rather limited use in Alaska. The lack of an adequate road system and the marshy nature of the terrain limited the use of such equipment to a few localities, and even there favorable winds are necessary for dispersal over the desired areas. An area sufficiently large to give any appreciable protection cannot be treated downwind from a single road, which is the typical road system in Alaska. Consequently, only a few towns and larger military posts could be treated with this type of equipment. Several plots half a mile square were treated on the downwind side of the road, but the mosquitoes returned so rapidly in plots of this size that the immediate reduction of adults was hardly apparent.

Airplane spray tests were conducted in 1948 to determine the area to be treated and the number of treatments that would be necessary to protect a community against mosquito adults infiltrating from surrounding untreated areas, and also the minimum effective dosage of DDT necessary for effective control. As previously mentioned, it was found that plots of 24 to 30 square miles must be re-treated every 7 to 10 days. When wind velocities were 0 to 5 miles per hour, 85 to 98 per cent immediate reduction of adult mosquitoes was obtained with a dosage of 0.1 pound of DDT per acre, or 0.5 pint of 20-per cent spray per acre. Only 32 per cent control resulted in a portion of one plot that was bordered by a high moraine when the spray was applied in winds as high as 15 miles per hour. A dosage of 0.05 pound per acre gave reductions of 73 to 85 per cent and 0.4 pound gave 91 to 93 per cent reduction. Under normal conditions 0.1 pound of DDT per acre apparently provided as good control as higher dosages.

Black Fly Larvae.—Comparative small-scale tests were made in streams with emulsions and with acetone and oil solutions of several promising insecticides. DDT, dichlorodiphenyldichloroethane, and methoxychlor were about equally effective and were superior to benzene hexachloride, chlordan, and chlorinated camphene. Parathion was more effective than other materials, but was not sufficiently superior to warrant its use in streams where fish are present. A dosage of 0.4 p.p.m. of DDT in fuel-oil solution applied to the surface of the streams was the most practical treatment indicated by these tests.

Because of the inaccessibility of streams, airplanes would be the most practical means of applying insecticides for the control of black fly larvae in Alaska. A number of streams were treated with airplanes by spraying one or more swaths across the stream to give a dosage of 0.1 pound of DDT per acre, or 0.5 pint of 20 per cent airplane spray. A 100-foot swath caused complete detachment of black fly larvae for 0.5 mile downstream. Swaths of 400 to 2400 feet caused larval detachment for 1 to 2.5 miles downstream. Further studies on aerial treatments of extensive areas are necessary to determine whether an entire community can be protected by this method.

Black Fly Adults.—In 1947 heat-generated DDT aerosols were tested against black fly adults on plots one-half mile

[1] C-47.

square. Even though the aerosols were applied under nearly perfect conditions, little reduction in adults was noted immediately after treatment. Apparently infiltration from the surrounding untreated areas occurred so rapidly that no immediate reduction was discernible. There was also some indication that the treatments were insufficient to kill the black fly adults. Further studies are needed to determine the dosages that would be effective against these pests.

Culicoides Adults.—The town of Valdez was treated on two successive nights with the heat-generated DDT aerosol for the control of *Culicoides* adults. Each time an area of about a square mile was treated under ideal conditions. More than 90 per cent control resulted from each treatment, but the breeding area could not be treated and infiltration began immediately after the smoke had cleared. The treatments, however, did provide some relief from annoyance during one evening.

REPELLENTS AND PROTECTIVE CLOTHING.—Comparative tests under field conditions were made with 10 of the most promising mosquito repellents. The repellents were applied to the skin in 25-per cent solutions in ethyl alcohol to reduce the period of effectiveness, as full-strength materials had been found effective for 5 or more hours. Tests were made against *Aëdes flavescens* (Muell.) and a mixed population of *A. communis* (Deg.), *A. excrucians* (Walk.), and *A. pionips* Dyar. The results with the four standard repellents and the best one of the new materials. the *n*-propyl ester of N,N-diethyl succinamic acid, are shown in table 1. All these materials gave longer protection against *A. flavescens* than against the mixed population.

In tests with *Culicoides* none of the repellent materials at full strength gave effective protection against biting. The 6-2-2 mixture and dimethyl phthalate were best, giving average protection of 49 and 42 minutes, respectively.

Tests were made with 35 materials to determine their effectiveness when impregnated with fabrics. The most effective of the materials was *n*-hexyl mandelate which remained effective after 13 rinsings and 40 hours' wear.

SUPPORTING STUDIES.—Specialists in various phases of biology and in equipment engineering were employed to gather

Table 1.—Average protection time provided by liquid repellents (25 per cent in ethyl alcohol) in skin tests against Alaskan *Aëdes* mosquitoes.

MATERIALS	*Aëdes flavescens*	MIXED SPECIES OF *Aëdes*
	Minutes	*Minutes*
N,N-Diethylsuccinamic acid, *n*-propyl ester	178+	92
1,2-Pyran-6-carboxylic acid, 3,4-dihydro-2,2-dimethyl-4-oxo-butyl ester (*Indalone*)	117	84
2-Ethyl-1,3-hexanediol (*Rutgers 6-12*)	115	71
Dimethyl phthalate	102	94
Dimethyl phthalate, *Rutgers 6-12*, and *Indalone* (6-2-2 mixture)	114	76

information bearing on insect control and to develop suitable means for applying insecticides under Alaskan conditions. Essential information was obtained on the following points: Biology and taxonomy of the insects, required for optimum timing of control programs; aquatic biology, particularly with regard to effect of the insecticides on fish and fish foods; correlation of plant associations with mosquito-breeding environments; effects of microclimate on insect activity; and the development and operation of the equipment.

Biology and Taxonomy.—In connection with the biological and taxonomic studies several general surveys were made along the entire road system in Alaska to determine the distribution and abundance of the various insect pests. It was found that every community had mosquitoes, *Culicoides*, black flies, snipe flies (*Symphoromyia*), or mixed populations of these insects in sufficient numbers to cause considerable annoyance. In many areas repellents and head nets were needed for protection against various pests from mid-April to late July.

Mosquitoes were abundant everywhere, as might be expected in view of the many square miles of environment favorable for their development throughout the territory. The most typical and widespread mosquito-breeding habitats were hummocky muskegs and bogs, old borrow pits, and road ruts in which the vegetation had returned. In fact, any depression that held water was a potential mosquito producer. The larger more permanent bodies of water usually produced a few mosquitoes along the margins.

At least 20 species of mosquitoes were

collected and identified, including 1 *Anopheles*, 1 *Culex*, 3 *Culiseta*, and 15 *Aëdes*. Larvae of *Anopheles occidentalis* D. & K. were commonly taken in pools and borrow pits where *Lemna* was present. An occasional adult was collected biting as early as April and May. Adults of *Culiseta alaskaensis* (Lud.) and *C. impatiens* (Walk.) were present in annoying numbers from the middle of April to about the first of July. The principal annoyance was caused by about five species of *Aëdes*—*punctor*, *communis*, *pionips*, *excrucians*, and, locally, *flavescens*. It was not uncommon for 100 mosquitoes to land on the front of one's trousers within a few minutes. Although these northern species are strong biters, they are not so aggressive as the salt-marsh species *Aëdes taeniorhynchus* (Wied.) and *A. sollicitans* (Walk.), which are common along the east coast of continental United States. Often relatively few mosquitoes would land, even though a cloud of several hundred might be hovering around one individual. *Culex apicalis* Adams was common, but was not taken biting man.

Culicoides are next in importance to mosquitoes as pests in Alaska. Little is known of their breeding habits in Alaska, although a few larvae and pupae were taken at the edge of a small river flood plain near Anchorage and from a tidal marsh near Valdez. This group is present in considerable numbers all over Alaska, and eight species in all were collected. All the species seemed to be aggressive biters, but the most severe annoyance observed was caused by two species, *C. tristriatulus* Hoffman and *C. yukonensis* Hoffman. These are very large species and are particularly abundant at Valdez (Fig. 1).

Black flies (Simuliidae) were present everywhere in the territory. They bred in practically every one of the innumerable streams. The determinations of collections are not yet complete for this group, but about two dozen species were collected. Only rarely did any of the black flies bite in Alaska but some of the same species are reported to bite man readily in other areas in North America. Considerable annoyance was experienced from the swarming of the flies around one's head and by their landing on the mouth, eyes, nose, and ears. When bites were received, the reaction was severe on most people. A large swelling, which itched intensely, persisted for about a week. So few bites were received that it was difficult to determine which were the most important species. Some of the most common species taken biting were *Simulium venustum* Say, *S. vittatum* Zett., and *Prosimulium fulvum* Coq. The greatest population seen was at Naknek, but even there bites were not numerous. One member of the survey group had about a dozen bites in nearly a week, although several hundred adults would be hovering constantly about each person. Although black flies were not very aggressive, they were important because of the severe reactions following bites.

No large populations of snipe flies (*Symphoromyia*) were encountered and, although rather aggressive, they were only mildly annoying. They were seen only in the more mountainous areas, particularly in the vicinity of Valdez. No study was made of their biology.

Five species of *Chrysops* and nine of *Tabanus* were collected. This group was common over all the territory, but they so seldom bit man that no special attention was given them other than to make collections to learn the species and distribution.

Large numbers of mosquitoes and black flies were reared individually so that the mature and immature forms of the various species could be recognized and associated. This procedure was of special importance in connection with the identification of mosquitoes, as the females of *Aëdes* are very difficult to determine, whereas the larvae are rather easily identified. It is hoped that studies will show characters suitable for determining these adults. Extensive collections and rearing of black flies during 1948 made possible considerable progress in identifying black fly larvae. All the material collected is to be deposited in the National Museum.

Aquatic Biology.—In the course of these studies the effect of several insecticides on fish and caddis flies, which are important fish food, was investigated. Rainbow trout, salmon, grayling, and caddis fly larvae were exposed in trough tests to determine the upper limit of tolerance to the insecticides. DDT was less harmful to the trout, salmon, and caddis fly larvae than were chlordan, chlorinated camphene, and benzene hexachloride. No injury from DDT was noted up to 30 p.p.m. when applied in acetone solution. DDT emul-

sions caused toxic symptoms at a dosage as low as 5 p.p.m. Fuel-oil solutions appeared to be about as toxic as acetone solutions. Caddis fly susceptibility was similar to that of fish. In comparative tests against grayling with acetone solutions of DDT, dichlorodiphenyldichloroethane, methoxychlor, and parathion, the highest concentrations that did not injure fish were 60, 80, 30, and 7 p.p.m., respectively.

Vegetation.—Observations were made on vegetation in a number of the study areas to determine the relationship between plant associations and mosquito-breeding habitats. In general the tussock-type muskeg areas were of greatest importance, largely because they constituted the major portion of the breeding area. Such areas might be divided into several rather distinct plant associations—various species of *Carex*, moss-heath-*Carex*, moss-heath, and moss-heath-*Myrica gale* or *Betula nana*. The correlation between plant associations and mosquito-breeding areas was sufficiently good that potential mosquito-producing areas could be located fairly accurately by low-level flights or by observations from the roads.

Climate.—Detailed observations were made on stream and pool temperatures, and microclimatic observations were helpful for determining whether reduced insect counts following spray applications were due to unfavorable weather or to the insecticides.

The streams and pools varied greatly in temperature even in the same immediate locality. Temperatures within pools were particularly variable, and in adjacent pools often differed so greatly that larvae were fully grown in one and very small in another. The horizontal and vertical temperature gradients in pools were exceptionally steep. Differences of 20° F. or more between the bottom and surface temperatures were not uncommon, and similar differences were found around the margins of the same pool.

In the studies on the effect of microclimate on mosquito and *Culicoides* activity, wind appeared to be of primary importance. Mosquito activity decreased rapidly with increased wind velocity, there being three times as many mosquitoes when the wind was below 1 m.p.h. than when it was between 2 and 3 m.p.h. *Culicoides* appeared unable to fly against winds stronger than 3.5 m.p.h. Insects in Alaska were active at low temperatures. Small numbers of mosquitoes were active and would bite at 45° F., and *Culicoides* activity dropped abruptly at temperatures lower than 55°. Additional observations were made on the effect of heat radiation, humidity, wind velocity, inversion temperature, air temperature, and barometric-pressure tendencies on insect activity. The correlation of these factors on insect activity has not yet been fully determined.

Equipment.—Improved spray-boom equipment was developed for a plane in which electric fuel-transfer pumps were used for the pressure system. Five pumps were installed, each of which would deliver 14.3 gallons per minute, or the equivalent of one-half pint of spray per acre with a swath of 800 feet. The droplets produced by this equipment, when delivering 1 pint per acre at a speed of 140 m.p.h., had a mass median diameter of 136 microns.

SUMMARY.—In cooperation with the Departments of the Army and Navy, extensive studies were made in 1947 and 1948 on mosquito and black fly (Simuliidae) larvae and adults and *Culicoides* adults in several sections of Alaska.

Prehatching treatments for the control of *Aëdes* larvae were effective only on some marshes. DDT, the most promising material tested, was more effective in fuel-oil solutions and in emulsions than in dusts. No difference was noted between fall and spring treatments. In conventional larvicide applications dichlorodiphenyldichloroethane, parathion, and methoxychlor were about as effective as DDT. Treatment of a 30-square-mile plot did not prevent infiltration of adults from surrounding areas.

Heat-generated aerosols were practicable for the control of adult insects only in areas where adequate crossroads were present, and such situations are very limited in Alaska. Plots of 24 to 30 square miles sprayed by air for the control of adult mosquitoes required retreatment every 7 to 10 days. A dosage of 0.1 pound of DDT per acre appeared to be adequate.

DDT, dichlorodiphenyldichloroethane and methoxychlor were about equal in effectiveness against black fly larvae and were superior to benzene hexachloride, chlordan, and chlorinated camphene.

Aerial applications of DDT at the rate of 0.1 pound per acre to swaths of 400 to 2400 feet across streams caused larval detachment for 1 to 2.5 miles downstream.

Comparative tests with promising repellents showed the four standard repellents and *n*-propyl N,N-diethylsuccinamate to be the best for skin application and *n*-hexyl mandelate for impregnation of clothing.

Surveys were made over most of Alaska to determine the species of biting flies and mosquitoes and their distribution and abundance. Large numbers were reared individually to permit recognition and association of mature and immature forms.

Studies on the effect of several insecticides on fish and fish food showed that DDT caused no damage to fish or fish foods at 30 to 60 p.p.m.

Good correlations were shown between plant associations and mosquito-breeding habitats and between the various microclimatic factors and the flight habits of mosquitoes and *Culicoides*.

Improved spray-boom equipment, which delivered droplets of 136 microns mass median diameter over a swath width of 800 feet, was developed for use on a testing airplane.

Corn Earworm Control with DDT and Other Insecticides[1,2]

GEORGE D. BUTLER, JR. and L. A. CARRUTH, *New York State Agricultural Experiment Station, Geneva*

The first reasonably effective insecticidal method for controlling the corn earworm, *Heliothis armigera* (Hubner), in sweet corn was the mineral oil treatment, developed by the late Dr. G. W. Barber (1942, 1944). This treatment consisted of the application of a small quantity of white mineral oil of high viscosity to the "silk channel," located between the tip of the developing cob and the external silks, at a time near the completion of pollination but before the appearance of appreciable numbers of earworm larvae. The control was found to be enhanced by the addition of a small quantity of another insecticide to the mineral oil (Barber 1942, 1943, 1944) (Carruth 1942). Among the insecticides used effectively in early tests were pyrethrum extract, dichlorethyl ether and styrene dibromide.

Preliminary tests of DDT against the corn earworm in 1943 under insectary and laboratory conditions (Ivy 1944) and on tomatoes (Johnson 1944) showed this new insecticide to be highly toxic. These results were confirmed in 1944 in tests made by Blanchard & Satterthwait (1945a, 1945b) for the control of the earworm in dent seed corn and in sweet corn, using DDT in mineral oil and in emulsions (on sweet corn only). Early tests in North Carolina (Anon. 1945) showed that DDT in mineral oil gave a higher degree of earworm control on corn than where pyrethrum or dichlorethyl ether was similarly used. DDT applied to sweet corn in the form of a liquefied gas aerosol was not effective in controlling the earworm in Maryland (Ditman 1946). Pepper & Wilson (1947) reported fair to good earworm control in New Jersey in three tests following single applications of 3 per cent DDT dust, although even better results were reported from the use of dusts containing dichlorodiphenyl dichloroethane Kulash (1948) reported good but not complete control of earworms from DDT dust and spray treatments. He also tested other, recently introduced insecticides, although complete control was not reported.

This paper summarizes tests for the control of the corn earworm in sweet corn which were conducted on western Long Island between 1945 and 1948.[3] During this period emphasis was placed on the evaluation of DDT in various formulations and schedules and in the comparison of DDT with other insecticide materials.

During 1945 comparisons were made between recommended mineral oil-insecticide formulations (containing 2 per

[1] Eastern Branch Program.

[2] Journal Paper No. 796, New York State Agricultural Experiment Station, March 7, 1949.

[3] The assistance of Messrs. L. M. Bartlett and E. H. Smith during the seasons of 1945 and 1946, respectively, is appreciatively recognized.

cent dichlorethyl ether and 2 per cent styrene dibromide, respectively) and DDT applied in mineral oil and in dust form. The results of one representative test are summarized in table 1. Oil-insecticide treatments were applied to the "silk channels" with a commercial applicator at the rate of 0.6 cc. per ear after the completion of pollination. Single DDT dust treatments were applied to the external silks, approximately one week after the mean silking date, by means of a bellows-type knapsack duster. A dust containing 40 per cent ground *Ryania* stem was also used in this test. The 1945 results indicated that DDT-mineral oil applications were more effective than mineral oil preparations containing dichlorethyl ether or styrene dibromide. DDT dusts were less effective than DDT-mineral oil mixtures, although 5 per cent DDT dust and 40 per cent *Ryania* dust showed definite insecticidal activity. Despite the effectiveness of the DDT-mineral oil mixtures, the health hazard associated with possible human assimiliation of residues of DDT dissolved in oil on kernels of treated ears appeared too great to warrant the consideration of such preparations for use by growers under practical conditions. Further tests therefore involved the use of DDT only in forms considered potentially less hazardous.

In 1946 unsatisfactory control was obtained by covering silks with sprays prepared from a wettable powder, containing 50 per cent DDT, used at the rate of 1 and 2 pounds per 100 gallons, respectively. Better earworm control was obtained with water emulsion sprays prepared by diluting a 25 per cent DDT emulsion concentrate (formulated for use on crops) to strengths of 2.5 per cent and 5 per cent, respectively, although very severe phytotoxic injury occurred on the husks and adjacent foliage. Further tests of three and five per cent DDT dusts, used in single applications, made approximately one week after the mean silking date, gave definite but inadequate earworm control.

In a test conducted during 1947 a single application of a 3-per cent DDT dust, applied as above, did not give a commercial degree of earworm control, although the results obtained were more effective than single applications, similarly applied, of dichlorodiphenyl dichoroethane, chlordan, or chlorinated camphene (each applied as 1, 3, and 5 per cent dusts) or of parathion (applied as 1 and 2 per cent dusts).

Table 1.—Effectiveness of single applications of mineral oil-insecticide treatments and of insecticidal dusts against the corn earworm, 1945. (100 ears examined per treatment.)

	NON-INFESTED EARS[1]	CONTROL EFFICIENCY
	per cent	*per cent*
Insecticides in mineral oil:		
2% dichlorethyl ether	79	68
2% styrene dibromide	77	65
1% DDT	89	83
3% DDT	88	82
5% DDT	93	89
Insecticidal dusts:		
40% *Ryania*	62	42
1% DDT	49	22
3% DDT	42	11
5% DDT	71	55
Untreated	35	—

[1] Includes only ears which were completely free from any earworm infestation or injury, even in the silks and other nonedible portions. This interpretation also applies to similar data in the succeeding tables of this paper.

By the end of the 1947 season it had become apparent that adequate corn earworm control was not possible with single applications of DDT dusts, as used during three seasons on western Long Island. In 1948 it was therefore decided to observe the degree of earworm control produced by from one to three dust treatments per ear, applied at different times in relation to the mean silking date. Five-per cent DDT dust was used for this test and was compared, in certain cases, with 5-per cent dichlorodiphenyl dichloroethane dust. The records from one 1948 test are summarized in table 2.

Although the control produced by one dust application was no better than in other years, a marked increase in non-infested ears followed the use of two or three dust applications per ear. Single applications were more effective when applied 6 or 8 days after the mean silking date than after 4 days. Two dust applications were more effective than one, although there was no significant difference between two treatments applied 4 and 6, 4 and 8, or 6 and 8 days after the mean silking date, respectively. Three dust treatments per ear appeared to be more effective than two treatments, although the difference was not great enough to be significant statistically. One,

Table 2.—Corn earworm control in relation to number and timing of applications of 5 per cent DDT and 5 per cent DDD dusts. Western Long Island, 1948.

Dust Used	Applications	Dates	Non-infested Ears	Control Efficiency
			per cent	*per cent*
5% DDT	1	Aug. 19	54.8	47.7
	1	21	74.0	69.9
	1	23	69.6	64.8
	2	19, 21	84.0	81.5
	2	19, 23	88.8	87.0
	2	21, 23	85.6	83.3
	3	19, 21, 23	95.2	94.4
5% dichlorodiphenyl dichloroethane	1	19	50.8	43.1
	2	19, 23	77.6	74.1
	3	19, 21, 23	86.8	84.7
Untreated:				
first series		—	16.0	—
second series		—	11.2	—
l.s.d. (5%)			14.4	

Sweet corn variety: Golden Cross Bantam; mean silking date: August 15, 1948. Test arranged in randomized blocks, replicated 5 times. Harvest infestation data based on five 50-ear replicate samples (250 ears total). Dusts applied to silks with a bellows-type, knapsack duster.

two, and three applications per ear of 5 per cent dichlorodiphenyl dichloroethane dust appeared to be somewhat less effective than corresponding numbers of applications of 5 per cent DDT dust, although the differences between the two materials were not entirely significant statistically.

During 1948, other recently introduced insecticides were tested in dust form against the corn earworm. Two such tests, which also included DDT and dichlorodiphenyl dichloroethane dusts, are summarized in table 3. In each case three dust applications per ear were made 4, 6, and 8 days, respectively, after the mean silking dates. Five per cent DDT dust gave the best results of the various mixtures tested. Other dust mixtures which produced 75 per cent or more non-infested ears at harvest, in one or both tests, included 3 per cent DDT, 5 per cent dichlorodiphenyl dichloroethane, 1 per cent parathion, 10 per cent of a dust prepared from an impregnated DDT and pyrethrum concentrate and containing 1 per cent DDT in the finished dust, and 10 per cent toxaphene. Less satisfactory control was obtained with dusts containing 5 per cent methoxychlor, 5 per cent chlordan, and 40 per cent ground *Ryania* stem, respectively.

The 1948 insecticide treatments described above were applied to the individual ears with bellows-type knapsack duster. An additional test was conducted with a more rapid method of application, using a hand-operated rotary-type duster, equipped with a "Y" outlet and capable

Table 3.—Corn earworm control produced by various insecticide dusts, each applied 3 times with a bellows-type knapsack duster. Western Long Island, 1948.

Dust Used	Test No. 1		Test No. 2	
	Non-Infested Ears	Control Efficiency	Non-Infested Ears	Control Efficiency
	per cent	*per cent*	*per cent*	*per cent*
3% DDT	80.8	74.7	—	—
5% DDT	93.6	91.6	85.6	82.3
4% Dichlorodiphenyl dichloroethane	78.0	71.1	74.6	68.8
1% Parathion	76.0	68.4	86.0	82.8
10% Special dust[1] (1% DDT present)	80.4	74.2	78.0	73.0
10% Toxaphene	69.6	60.0	81.0	76.7
5% Methoxychlor	62.4	50.5	66.6	59.0
5% Chlordan	55.6	41.6	50.0	38.7
40% *Ryania* stem	60.0	47.4	53.0	42.3
Untreated:				
first series	28.4	—	18.0	—
second series	19.6	—	19.0	—
l.s.d. (5%)	8.9		12.4	
Sweet corn variety:	Magnagold		Magnagold	
Mean silking date:	August 12		August 19	
Treatment dates (bellows-type knapsack duster used)	August 16, 18, 20		August 23, 25, 27	
Harvest dates	September 2, 3		September 7	
Total no. ears examined	250		200	
Number of replicates	5		4	

[1] "P-M" impregnated dust concentrate is a product of McLaughlin Gormley King Co., containing 10 per cent DDT, 1.2 per cent pyrethrins and 36.8 per cent petroleum hydrocarbons.

of treating two rows at a time in a manner comparable to that of a row crop duster. The results of this test are summarized in table 4. The percentage of non-infested ears was only slightly lower than where the bellows-type duster was used and the dusting operation was more rapid and less laborious. Two or three applications of 5 per cent DDT dust were necessary for satisfactory results. On the basis of the 1948 tests, the use of power-operated, row crop dusting equipment of adequate axle clearance appears worthy of consideration for corn earworm control on Long Island.

In the data summarized in the foregoing tables the harvest records are expressed in terms of non-infested ears, completely free from corn earworm infestations or injury. In each test a small additional percentage of ears occurred which could be classified as "infested but salable," in which only the silks or ear tips were affected. Under practical conditions the actual salable yield from adequately treated sweet corn plantings should, therefore, be higher than the figures indicate.

Table 4.—Corn earworm control in market sweet corn using insecticides applied by a hand-operated rotary duster treating two rows at a time. 1948.

Dust Used	Number of Applications	Dates of Application[1]	Non-Infested Ears
			per cent
5% DDT	1	August 19	54.8
	2	19, 23	82.4
	3	19, 21, 23	86.8
5% Dichlorodiphenyl dichloroethane	3	August 19, 21, 23	74.0
Untreated	—	—	24.4
l.s.d. (5%)			8.9

[1] Mean silking date: August 15.

In the consideration of DDT dusts for use on sweet corn, applied approximately 2 weeks before harvest, attention must be given to a possible residue problem. During the 1948 season a number of samples of dusted ears were analyzed[1] for possible residues. Three series of husk tip samples, taken from ears which had received 3 applications of 5 per cent DDT dust, showed DDT residues of 35, 170, and 474 parts per million, respectively. Four series of husked ear-tip samples, representing the actual edible portion of the ear, from plots which received three applications of 5 per cent DDT dust, showed DDT residues of 0.6, 0.6, 0.2, and less than 0.1 parts per million, respectively. These latter residues are not considered a serious menace to health on the basis of information now available. The above analyses were made from samples taken from the tip third of the husks and ears. Since the dusts were directed at this portion of the plant, it may be questioned whether whole-plant samples would contain sufficiently high residues to preclude the use of the stalks of treated ears as food for livestock, although the husks of treated ears should probably not be used for this purpose.

Further investigations should be directed toward the development of an insecticidal formulation at least as effective and as easy to apply as 5 per cent DDT dust, described above, but without the corresponding residues on the harvested product. One possible alternative may be the use of impregnated DDT formulations similar to the special dust shown in table 3. Although the finished dust contained only 1 per cent DDT, it produced 80.4 per cent non-infested ears as compared with 80.8 per cent and 93.6 per cent non-infested ears in plots where 3 per cent and 5 per cent DDT dusts, respectively, were used. Parathion formulations should be investigated further, particularly if the residue hazard is shown to be less serious than in the case of DDT. In September 1948 harvest analyses of husks showed 0.29 and 1.34 parts per million of parathion where one application and three applications (at 2-day intervals), respectively, of 1-per cent parathion dust were applied. Analyses of the husked ears failed to show traces of parathion in either case.

SUMMARY.—Insecticide tests conducted for the control of the corn earworm on western Long Island between 1945 and 1948 are summarized, in which various DDT formulations and schedules were evaluated and comparisons were made between DDT and other insecticide materials. Preparations of DDT dissolved in mineral oil were more effective than similar formulations containing dichlorethyl ether or styrene dibromide when applied to the silk channels at the rate of 0.6 c.c. per ear after the completion of pollination. Single applications of DDT sprays, prepared from wettable powder, and of 3 and 5 per cent dust formulations resulted in inadequate earworm control. In further

[1] Through the courtesy of Dr. A. W. Avens, Division of Food Science and Technology, New York State Agricultural Experiment Station.

tests of 5-per cent DDT dust a marked increase in non-infested ears followed the use of two or three applications per ear. There was no significant difference between two treatments applied 4 and 6, 4 and 8, or 6 and 8 days after the mean silking dates, respectively. Three dust treatments per ear appeared to be more effective than two, although the difference was not great enough to be entirely significant. In comparative tests of insecticides in dust form, each applied three times per ear (4, 6, and 8 days after the mean silking date, respectively), 5-per cent DDT gave the best control. Other dust mixtures which produced 75 per cent or more non-infested ears at harvest, in either or both of two tests, included 3 per cent DDT, 1 per cent DDT (prepared from an impregnated DDT-pyrethrum-oil concentrate), 5 per cent DDT, 1-per cent parathion, and 10-per cent toxaphene. Analyses of husked ears from DDT-dusted plots showed only negligible DDT residues, although more substantial residues were present on the husks. Similar analyses of ears dusted with 1-per cent parathion revealed no residues on the husked ears and relatively low parathion residues on the husks.

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Use of White Mice for Testing Materials Used as Repellents and Toxicants for Stable Flies

GAINES W. EDDY and W. S. MCGREGOR, *U.S.D.A., Agr. Res. Admin., Bureau of Entomology and Plant Quarantine*

This paper describes a method whereby white mice can be utilized as test animals for making preliminary evaluations of materials as repellents and toxicants against the stable fly, *Stomoxys calcitrans* (L.). So far as is known, this is the first time mice have been used for this purpose. Travis *et al.* (1946) used humans for testing materials as repellents against stable flies in the laboratory. Most of the tests made in the past have been conducted under semi field and field conditions, with cattle as the test animals.

Tests with certain compounds are described to show the relation between the data obtained in the laboratory with mice and those obtained with the same materials tested on cattle under semi field or field conditions.

MATERIALS AND METHODS.—*Tests with White Mice.*—Adult white mice weighing 25 to 30 grams were used as test animals. Preliminary tests were made with various organic solvents containing no insecticide. It was found that mice did not survive dipping in most of the solvents but that they could tolerate a thorough wetting with acetone applied as a spray.

Since it was difficult to spray mice adequately by ordinary methods, a machine was built for that purpose (Figure 1) out of an old-style phonograph. The

cylindrical record-holder was replaced by a removable cylindrical cage constructed of quarter-inch mesh wire screen. The diameter of the cage was such that the mouse could be firmly held. A metal baffle plate with an orifice slightly larger than the cage was placed in front of the cage, and another metal plate behind the cage protected the machine from the spray. The excess spray solution drained into a trough placed under the two plates.

The spray was applied with an electric air-blowing paint sprayer in which the regular container had been replaced with a shell vial. The nozzle of the sprayer was adjusted to produce a finely atomized spray, which was expended at the rate of approximately 1.5 ml. per second. The revolving mechanism was set to turn the cage once per second, and during the spraying the mouse was revolved seven times. Tests with a dye solution indicated that the spray wetted the mouse uniformly, penetrating to the skin over the entire body.

When insecticide solutions were applied, the sprayer was allowed to run for a few minutes after the solution was expended. The air current caused the acetone to evaporate rapidly, and the dry mouse was transferred to a holding cage.

Each mouse was sprayed with 10 ml. of a 1 per cent solution of the candidate material dissolved in acetone containing 2 per cent of a polyoxyalkylene derivative of sorbitan monolaurate. Twenty-four hours later the mouse was exposed to stable flies that had been starved for approximately 20 hours. The mouse was placed inside a quarter-inch mesh wire cylinder, which was made adjustable so that the mouse could be firmly held. This small cylinder was suspended inside a screen-wire cylinder 8 inches high and 3.5 inches in diameter, in which 20 flies were also placed. Flies 2 to 6 days old were used in all the tests, which were conducted at $80 \pm 2°$ F. and a relative humidity between 50 and 70 per cent. Care was taken to see that the sex ratio of the test flies was approximately 50–50. After 1 hour the mouse was removed and the engorged flies were counted. The flies were then fed citrated blood, and after 24 hours mortality records were taken. Materials allowing as many as 20 per cent of the flies to engorge in 1 hour were not tested further.

Tests on Cattle.—The cattle used in the study were yearling Jerseys. Wettable powders or emulsion concentrates of the insecticides were diluted with water to desired concentrations and applied with a power sprayer at a nozzle pressure of approximately 50 pounds per square inch. The animals were turned out to pasture after the spraying.

FIG. 1.—Machine for spraying mice, with baffle plate removed.[2]

At desired intervals thereafter, animals were confined separately in outdoor screen cages measuring approximately 8 by 10 by 7 feet. In each cage 100 stable flies were released. If the treatment was not repellent, the flies immediately flew to the cattle to feed. The duration of repellent effect was observed and, in the case of nonrepellent treatments, speed of knockdown was noted. When flies which had fed on treated cattle were not affected after 8 hours in the outdoor cages, engorged flies were captured and held in the laboratory for an additional 24 hours for mortality determinations.

RESULTS.—When sprayed on mice at 1 per cent concentration, the following materials gave incomplete protection from stable flies 24 hours after application, allowing at least 30 per cent of the flies to feed: Dimethyl phthalate; dibutyl phthalate, *n*-butyl mesityl oxide oxalate, (2-ethyl-1,3-hexanediol), cis-bicyclo-(2,2,1)-heptene-2,3-dicarboxylic acid the dimethyl ester of N-(*n*-butyl)-N-phenylacetamide, and 1-(*p*-methoxyphenyl)-2-methyl-1,3-propanediol methylene ether. In cage tests these materials proved ineffective on cattle 24 hours after application. Five of them were also sprayed on

[1] Such all-purpose solutions are routinely made for screening tests conducted at the Kerrville, Tex., laboratory against a variety of livestock pests. In these particular tests *Tween 20* was not essential.

[2] Constructed by C. N. Husman.

cattle that were exposed after 24 hours to stable flies in nature. All five treatments proved completely ineffective.

Mice sprayed with 0.1 per cent of pyrethrins (prepared from a 20 per cent pyrethrum extract) were protected from stable flies for 2 to 3 days. Cattle sprayed with an aqueous emulsion containing the same concentration of pyrethrins were protected for 24 but not for 48 hours.

When tested alone at 1 per cent, piperonyl butoxide showed some repellency to flies in tests on mice but none in tests on cattle.

In tests with mice methoxychlor repelled flies for 3 days when applied at 0.5 per cent concentration but gave little protection after 5 days. The treatment caused complete kill of the feeding flies for the first 4 days and partial kill for 7 days. Almost identical results were obtained in cage tests with cattle in which methoxychlor was applied as a 0.5 per cent wettable-powder suspension.

Dichlorodiphenyldichloroethane sprayed on mice at 0.5 per cent concentration prevented feeding for the first 24 hours, but when sprayed on cattle at the same concentration it showed no repellency after 24 hours. The material caused complete kill of the flies feeding on mice for the first 3 days and partial kill for five days. Similar results were obtained in cage tests with cattle.

DISCUSSION.—Of approximately 150 compounds sprayed on mice, about 20 have shown sufficient promise to warrant further investigation. Since these compounds have given good protection for as long as 24 hours when used at 1 per cent, this concentration used on the mice appears satisfactory for revealing the more effective compounds.

It is believed that the mouse technique offers a reliable screening procedure for the study of stable fly repellents and toxicants. The use of mice instead of cattle has many distinct advantages. Compare the efficiency and cost of spraying 25 head of cattle, each with a different material, with that of spraying 25 mice. Furthermore, the material may not be readily available in sufficient quantities for treating even one large animal. Tests on mice can also be made the year around instead of only during the fly season.

SUMMARY.—A method is described whereby white mice are utilized as test animals for making preliminary evaluations of materials as repellents and toxicants for the stable fly, *Stomoxys calcitrans* (L.). The materials are applied to the mice as acetone solutions with an electric air-blowing paint sprayer. Twenty-four hours after treatment the mice are exposed to hungry flies to determine the degree of repellency and the toxicity of the materials to the feeding flies.

The results obtained with several materials, including pyrethrum, piperonyl butoxide, methoxychlor, and dichlorodiphenyl dichloroethane, when applied as sprays on mice and on cattle are shown. The results obtained on mice appeared sufficiently comparable to those obtained on cattle to warrant the use of mice as test animals in the study of stable fly repellents and toxicants.

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IN RETROSPECT
FIRST MEETING OF AAEE

Mr. James Fletcher, president of the Entomological Club of the American Association for the Advancement of Science issued a call to those interested in the formation of an Association of Official Economic Entomologists, and as a result an organization meeting was held at Toronto, Canada, on August 29 and 30, 1889. A constitution was adopted at this meeting and C. V. Riley was elected president, S. A. Forbes, first vice-president, A. J. Cook, second vice-president, and John B. Smith, secretary. In all there were about 23 charter members.

Hibernation and Host-Plant Studies of the Mexican Bean Beetle in California

JOHN C. ELMORE, *U.S D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

The Mexican bean beetle, *Epilachna varivestis* Muls., was found on lima beans at Montalvo, Ventura County, California, in July 1946. This was the first known infestation of this pest on the Pacific coast. Armitage (1947) gives an account of its occurrence and details of the suppressive measures undertaken by the California Department of Agriculture and by Ventura County. At the request of the California Department of Agriculture the writer was assigned, on December 1, 1946, to undertake studies on the hibernation of the Mexican bean beetle and the wild host plants of the insect in Ventura County. The studies were made in cooperation with the California Department of Agriculture and the Ventura County Agricultural Commission and were continued until August 1, 1947. The study of the wild host plants, particularly of the pea family, indigenous to Ventura County was included in order to determine their importance in the eradication campaign waged against this grave pest. By the time the writer arrived, the bean beetle population had been greatly reduced by an insecticidal control program. All the beans had been harvested and the bean beetles remaining in the field were in hibernation.

HIBERNATION.—Most of the Mexican bean beetles apparently had sought shelter near the margins of bean fields in which they had been feeding about harvest time. Their numbers in these marginal areas decreased rapidly as the distance from bean fields increased. None were found hibernating more than half a mile from the bean fields. The beetles were found beneath leaves and debris at the base of eucalyptus, English walnut, cypress, and lemon trees, and also at the base of grapevines, pole beans, and around irrigation standpipes. The beetles found beneath English walnut trees were commonly associated with wild morning-

Table 1.—Emergence of Mexican bean beetles from hibernation, as indicated by their activity in lima bean fields and in a hibernation cage, in relation to temperature and precipitation and to the development of lima bean crop. Ventura, California, 1947.

Date	Temperature °F.			Precipitation	Bean Fields Planted	Fields in Which Beans Were Up	Beetles Found in Field	Beetle Emergence in a Hibernation Cage	
	Min.	Max.	Mean						
				Inches	*Number*	*Cumulative number*	*Number*	*Number*	*Cumulative percentage*
March 26–31	49	78	60 4	0.69	0	—	—	5	2.0
April 1– 5	40	68	55.3	0	0	—	—	1	2.4
6–10	44	81	57.7	0	0	—	—	5	4.5
11–15	52	96	71.7	0	0	—	—	2	5.3
16–20	48	73	60.8	0	1	0	—	2	6.1
21–25	46	69	58.5	Trace (fog)[1]	2	0	—	2	6.9
26–30	47	74	59.9	0	3	1	0	1	7.3
May 1– 5	50	82	64.1	0	9	3	0	4	9.0
6–10	46	79	61.6	0 (fog)[2]	8	6	0	0	9.0
11–15	47	71	59.5	0 (fog)[2]	7	15	1	0	9.0
16–20	47	69	59.6	Trace (fog)[1]	4	23	1	11	13.5
21–25	52	74	61.9	Trace (fog)[1]	5	30	6	9	17.1
26–31	49	75	61.1	0.11	1	34	1	18	24.5
June 1– 5	50	74	62.5	Trace (fog)[1]	0	39	5	10	28.6
6–10	55	76	64.2	0 (fog)[2]	0	40	20	18	35.9
11–15	54	81	67.1	0	0	40	6	3	37.1
16–22	52	77	64.6	0.03	0	40	23	7	40.0
23–28	52	75	62.8	0	0	40	28	0	40.0
29 to July . 5	47	77	62.1	0	0	40	1	0	40.0

[1] Fog heavy enough to produce a trace of precipitation in the rain gage.
[2] Heavy fog producing surface moisture, but not sufficient to accumulate in the rain gage.

glory plants, which remained green throughout the winter. The beetles apparently sought these plants for protection, as it was subsequently determined that this species of morning-glory was not fed upon by the bean beetle.

The beetles in their winter habitat sought moist conditions. For example, during wet periods they were to be found among leaves and debris, but during dry weather they were usually found next to the moist soil beneath the debris, and occasionally in soil crevices.

A wire-screen cage, 3 by 3 by 3 feet, containing leaves of eucalyptus, cypress, walnut, and mesembryanthemum, was placed in partial shade to simulate hibernation conditions in the field. A total of 245 Mexican bean beetles were put in this cage—150 on September 27 and 95 on October 11, 1946. In order to prevent the beetles from escaping, the cage was protected by a heavy wire-screen cover and was provided with a safety entrance.

Beetle activity in the cage and air temperatures in a standard shelter a few feet away were observed daily. Lima bean fields in the area that had been infested in 1946 were examined each week for beetle infestation. Planting dates in relation to beetle emergence were observed in 40 of these fields (Table 1). On February 14, 1947, following a light rain, two beetles in the cage were active but were not removed. Except for one active beetle on February 21 no more activity was noted during the month. Although February was unusually warm, this activity did not appear to be associated with temperature, as the first and fourth days of the month were the warmest. On March 28 four beetles were active, but during the first 27 days active beetles were noted on only 14 days and never more than two at a time. Beginning on March 28 all active beetles were removed at each daily observation, and were considered to have emerged from hibernation. At this time lima beans were up in many gardens, but it was not until the latter part of April that lima beans in commercial fields came up. As shown in table 1 only 40 per cent (98) of the beetles in the hibernation cage survived the winter. The last beetle became active on June 22, 68 days after emergence was considered to have begun, and 4 months after the first activity had been noted. The first beetle in the fields was observed on May 13, at which time 9 per cent of those in the cage had become active. A total of 92 beetles was collected in the 40 fields under routine observation. Most of these were found during the last 3 weeks of June, whereas, emergence in the cage was most rapid from the middle of May to the middle of June.

The light field infestation, consisting of only 92 beetles, 100 larvae, and 49 egg clusters from May 13 to July 5, was due to suppressive measures by the California Department of Agriculture, rather than to mortality from exposure to adverse weather conditions during hibernation. The beetle population in natural hibernation quarters was materially reduced during February by raking the litter from all known hibernation places, burning it, and spraying the soil with pyrethrum, as described by Armitage (1947). The field infestations were controlled by applying rotenone dust to each field as soon as the first beetle on beans was found.

The relation of bean beetle emergence to temperature and precipitation agreed closely with observations made by Howard & English (1924) in Alabama, and Douglass (1928, 1933) in New Mexico. High temperatures of 84° to 96° F., April 11–14, accompanied by low humidity did not bring a corresponding increase in beetle emergence. Beetles emerged in numbers only during or following precipitation or during heavy fogs that left everything damp. However, the rainfall in 1947 for the coastal area of southern California was the lowest on record. The collection of adults in the lima bean fields demonstrated that in California the Mexican bean beetle is able to survive severe drought conditions and to infest the spring crop.

HOST-PLANT TESTS.—Various wild plants were tested as possible hosts of the Mexican bean beetle by transplanting them to flower pots in the greenhouse and infesting them with adults and larvae of the beetles. The number of plants of each species which could be tested was limited by the number of beetles available. Therefore, some of the plants were tested only once, whereas those indicating possibilities of being hosts were tested a maximum of 7 times. Screen-wire cages 6 by 12 inches were used for testing beetles, and lantern-globe cages 5 by 9 inches for testing small larvae.

Beetles which had been held in outdoor cages until the greenhouse was available, and those emerging from the hibernation cage were used in these tests as long as the supply lasted, and then greenhouse-reared beetles were used. A few preliminary tests were made with larvae 8 to 14 days old, but when probable survivalwas indicated, further tests were made with newly hatched larvae. Five beetles and the larvae from a single egg cluster of about 35 eggs were used as a unit number of insects for plant tests, except in a few preliminary tests where as few as 8 partly grown larvae were used. All tests with both larvae and adults were continued until all of the insects had died, or in the case of plants on which the beetles would not remain, there was evidence that the plants were unfavorable to the beetles.

Plants were classed according to the results of these tests as follows:

Plants on which beetles would not remain:

Loco weed, *Astragalus antisellii* Jepson, 1 test
Burro fat, *Isomeris arborea* Nutt., 1 test
Malva, *Malva borealis* Wallm., 1 test

Plants on which the beetles would remain but would not feed:

Wild pea, *Lathyrus strictus* Nutt., 1 test
Morning-glory, *Convolvulus arvensis* L., 2 tests
Vetch, alsike clover, sweet clover, horse bean, 1 test each
Deer weed, *Lotus salsuginosus* Greene, 3 tests; and *L. scoparius* (Nutt.) Ottley, 2 tests
Lupine, *Lupinus bicolor* Lindl., 1 test; and *L. truncatus* Nutt., 1 test

Plants on which larvae and adults fed, but on which no reproduction occurred:

Lupine, *Lupinus hirsutissimus* Benth., 2 tests; *L. excubitus* Jones, 4 tests; and *L. succulentus* Dougl., 7 tests.

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Some Overlooked Relationships of Southern Pine Beetle

L. A. HETRICK, *College of Agriculture, University of Florida, Gainesville*

Perhaps no forest insect has had more publicity in the southeastern United States than the southern pine beetle, *Dendroctonus frontalis* Zimm. The name of the insect is well-known to foresters and entomologists yet few are able to distinguish bark engravings of southern pine beetle from those of other bark beetles attacking pine. The sporadic appearance of southern pine beetle in great numbers and its devastating effect on stands of pine timber are not quickly forgotten by those who have witnessed outbreaks of the insect. Much stumpage value has been lost due to the depredations of this insect. The purpose of this paper is to record certain misunderstood relationships between southern pine beetle and the trees. A previously unreported possibility for control is presented.

RAINFALL.—Deficiencies in rainfall, dry weather, and drought have long been associated with outbreaks of southern pine beetle. Craighead (1925) correlated rainfall deficiencies with several outbreaks of southern pine beetle, and St. George & Beal (1929) and St. George (1930) have offered further substantiating proof that increases in the populations of southern pine beetle follow deficiencies in rainfall. Even prior to this, Felt (1914) and Blackman (1924) had pointed out that populations of the tree-killing hickory bark beetle, *Scolytus quadrispinosus* Say, built up enormous populations and killed many trees in seasons of scanty rainfall. Foresters and entomologists have accepted this explanation, and drought and dry weather are always the first thought whenever an outbreak of southern pine beetle is encountered.

Undoubtedly the lack of sufficient

precipitation has had a profound effect on the development of many epidemics of southern pine beetle in the past. However, it is the purpose of this paper to put on record a recent outbreak of southern pine beetle that cannot be attributed to a rainfall deficiency. In 1946 and 1947 this bark beetle killed second growth loblolly pine, *Pinus taeda* L., on more than 3000 acres in Marion County, Florida. Rainfall had been excessive and had brought about a general increase in the level of the water table in the soil. Although excessive precipitation was recorded throughout north central Florida for this same period, the Marion County location was the only area in which this bark beetle was known to be active. An examination of U. S. Weather Bureau records for Ocala (about 10 miles northwest of the infested area) shows the general excess of precipitation (Table 1).

Table 1.—Monthly and annual departures from normal rainfall at Ocala, Florida.

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE
1945	+1.98	−2.45	−3.45	−0.77	−2.75	+2.13
1946	+0.13	+1.95	+0.03	−1.29	+3.51	+0.99
1947	−1.42	+1.38	+3.95	+4.53	−1.74	−2.18

JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL
+5.67	+2.83	+2.16	−1.45	−1.06	+4.42	+ 7.26
+1.28	+2.74	+2.96	+3.21	−0.78	−2.93	+11.80
+3.69	−0.12	+3.32	+1.16	+1.62	−1.40	+12.79

Excessive precipitation continued into 1948 and the outbreak of southern pine beetle subsided early in the year. Unfortunately a detailed study of the decline of the insect could not be made. Infested bark collected in December 1947 was found to contain dead and dying brood parasitized by a nematode previously observed by the writer (1940). However, it is not possible to say definitely that this parasite was responsible for the termination of the outbreak.

Although this outbreak of southern pine beetle was associated with an excess of precipitation, the effect of this excess of moisture on the vitality of the trees was similar to an extended period of deficient soil moisture. Either extreme may bring about conditions within the tree that are favorable for attack by southern pine beetle. In other words, any disturbing influences that interfere with normal functioning of the root systems of the trees may induce bark beetle attack.

To substantiate further the reasoning that the root systems of the trees are the important consideration in determining susceptibility of trees to bark beetle attack, other observations on this subject are worthy of presentation. In the course of more than 10 years the writer has observed many pine trees infested with southern pine beetle and other bark beetles. Several instances of pine trees actively infested with southern pine beetle and with rhizomorphs of the mushroom root rot, *Armillaria mellea* (Vahl), between the bark and sapwood of the stump region, have been observed. Callus sapwood growth, at the points where the fungus mycelium was growing upward, clearly indicated that the fungus preceded the bark beetle attack. Hepting (1940) has commented briefly on the destructiveness of *A. mellea* to coniferous trees, though for the most part this disease has received little attention from pathologists in the United States. Since the root systems of the trees are difficult to observe, is it not possible that *A. mellea*, other diseases of the roots, and possibly root-infesting nematodes may be tree-weakening factors that precede bark beetle attack?

Further evidence that injuries to the roots of pine trees are of greatest importance in making the trees attractive to bark beetles has been found through a study of trees injured by lightning. Usually lightning injury follows the trunk of the tree to the ground and bark beetle attack soon follows. St. George (1930) has commented on lightning injury and the attractiveness of trees so injured to southern pine beetle. However, in some few cases lightning injury to pine trees is not followed by bark beetle attack. Where the electrical injury is to the top and trunk only and where the charge is grounded by some route other than the root system of the tree, bark beetle attack does not usually follow. Additional evidence of the importance of root injuries can be found in the extensive naval stores forests of the southeastern United States. Turpentine faces constitute a rather severe injury to the trunks of the trees yet these trees are not attacked and killed by bark beetles unless the roots of the trees are also injured.

BLUESTAIN RELATIONSHIPS.—A dark stain of the sapwood of pine trees is usually associated with trees killed by southern pine beetle. This staining is

caused by the fungus *Ceratostomella pini* Munch and is apparently transmitted incidentally from tree to tree by the winged adult beetles. Quite likely an indirect relationship of fungus transmission exists and is connected with mites that are ectoparasites of the bark beetles. Leach *et al.* (1934) have pointed out that although the intestinal tracts of larvae and adults of bark beetles are contaminated with fungus spores, no internal contamination of eggs and pupae could be found. These same workers found mite parasites of bark beetles to be externally contaminated with spores of the stain fungus. In southern pine beetle there is no contact with the fungus-infected region of the tree after early larval development. Perhaps emerging bark beetles would be free of contamination were it not for the mites that accompany them to new trees.

St. George & Beal (1930) have stated that blue-staining is always associated with southern pine beetle attack. Craighead (1928) has written that without the aid of the bluestain fungi the bark beetles would be unable to kill the trees so quickly. In the Marion County, Florida outbreak of 1946-48 many infested trees showed no evidence of blue-staining. These trees did, however, die rapidly and they produced normal broods of bark beetles. Similar observations, in other areas, of pine trees infested by southern pine beetle have convinced the writer that the presence of *Ceratostomella pini* is not essential for successful attack by this bark beetle.

DROWNING OF LARVAE.—Many outbreaks of southern pine beetle have terminated after normal or excessive rainfall has been resumed in the infested area. Craighead (1925) and St. George & Beal (1929) have commented on this relationship. Although these authors have not stated that the bark beetles and their broods were drowned, most foresters and many entomologists have this general impression. "Drowned" southern pine beetle brood has been shown to the writer on several occasions after heavy rains. The limp and water-logged larvae certainly do present a lifeless appearance but they have not been drowned. Several days later examination of the trees from which bark samples had been collected showed that the insects were alive and apparently normal.

An experiment on drowning of southern pine beetle was conducted while the writer was employed by the Virginia Agricultural Experiment Station. Infested bark containing overwintering brood was collected from a loblolly pine in March. This bark ranged in thickness from 0.5 to 1.5 inches in thickness and contained a fairly uniform population of larvae and prepupae in cells in the corky bark. Some of this infested bark was thrown into tubs of water under outdoor conditions; another lot of the bark was kept covered with moist burlap sacks in the insectary as a control. Samples of the bark were removed from the tubs at intervals and dissected to determine mortality. Results are presented in table 2.

Table 2.—The effect of water immersion on brood of southern pine beetle.

TIME IN WATER	LARVAE ALIVE	LARVAE DROWNED	PER CENT MORTALITY
7 days	184	11	5.64
11 days	219	17	7.20
15 days	258	27	9.47
21 days	211	63	22.99
28 days	138	44	24.17
36 days	141	133	48.54

When the water-soaked bark was dissected, practically all of the larvae and prepupae were limp, lifeless, and watery in appearance. These insects were placed in petri dishes and many of them recovered within a few hours. Counts were not made until 18 hours after removal of the insects from the bark; specimens that exhibited no life were considered as drowned.

Air temperatures during the period of the test were low and ice covered the bark and water on several mornings. The lowest temperature during the period of test was 24° F.; the maximum for the same period was 83° F.

Bark from the same pine tree, held in the insectary as a control, exhibited a normal development of southern pine beetle, and adult emergence took place early in May. Since brood development was arrested by placing the bark in water, the control is not exactly comparable to the bark used in the test. However, the control did show normal development as contrasted to arrested development in the test. A mortality of 5.56 per cent was recorded from the control during the 36-

day test period. This mortality was attributed to insect predatism, parasitic nematodes, parasitic fungi, and moult mortality. During the 36 day test period 80.45 per cent of the insects in the control had transformed to pupae.

The factors of predatism and moult mortality did not operate in the bark in the water because insect activity and brood development were arrested soon after the bark was placed in water. Larvae of the predaceous Clerid beetle. *Thanasimus dubius* Fab., failed to revive after 21 days in the water. In all of the bark dissected from the test and from the control, no insect parasites of southern pine beetle were encountered.

Although drowning the southern pine beetle appears to be difficult to accomplish the experiment does present a possibility for control that has been overlooked in the past. Burning of the bark of infested trees has long been recommended as a control for this bark beetle. Not only is the bark difficult to burn but such procedure is often attended with considerable hazard to the woodlands from escaped fires. In many cases, southern pine beetle infestation is near a pond or sluggish stream into which infested bark could be dumped. Once the bark is placed in the water, brood development is arrested. Since there would be no reason for removing the bark from the water, no emergence of adult beetles would take place and a substantial reduction in the population would be effected.

SUMMARY.—Excesses as well as deficiencies of rainfall may contribute to outbreaks of southern pine beetle. Damage to the root systems of the trees contributes more attractiveness to bark beetles than damage to the trunks and crowns of the trees. The bluestain fungus does not always accompany southern pine beetle; the insect can infest trees and develop healthy broods without the aid of this fungus. Brood of southern pine beetle is not easily drowned but the dumping of infested bark into ponds or sluggish streams offers a previously unreported control possibility. Brood development is arrested when the bark is placed in water; since no adult emergence would follow such treatment, substantial reduction of populations could be accomplished.

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NEW JERSEY SHORT COURSES FOR PEST CONTROL OPERATORS

Since 1944, a series of short courses have been held jointly by the College of Agriculture, Rutgers University, and the New Jersey Pest Control Association, Incorporated, covering such subjects as insect identification, rodent control, termite control, chemistry of insecticides, etc. The last course, which was held January 17 to 19, 1949, covered insects and their environment and was largely conducted by Dr. John B. Schmitt and Dr. Robert S. Filmer under the overall direction of Dr. Bailey B. Pepper. Thirty pest control men attended the lecture and laboratory sessions.

Effect of Formulations of DDT, and of Chlordan on Potato Flea Beetles and Yield

NEELY TURNER and NANCY WOODRUFF, *Conn. Agr. Expt. Sta., New Haven*

Differences in control of potato aphids following applications of DDT spray powders and emulsions have been recognized generally. Gyrisko *et al.* (1946) presented data which showed that emulsions were more effective than spray powders in most cases. Rawlins (1946) stated that about one-fourth as much DDT was required in the form of an emulsion as in a spray powder to provide equal control of aphids. Bronson & Smith (1946) found that emulsions were considerably more effective than spray powders in controlling aphids. Glasgow (1946) reported similar results for control of pea aphids. Voss & Andre (1948) added further data confirming the effectiveness of emulsions for control of potato aphids. In addition to the data on aphid control, Gyrisko *et al.* (1946), Rawlins (1946) and Sleesman & Wilson (1946) either stated or implied that an emulsion was as effective as spray powder for controling other pests of potatoes, such as flea beetles and leafhoppers. Kulash (1947) found that the emulsions were more effective than spray powders for control of the Colorado potato bettle.

On the other hand, Woodruff & Turner (1946) and Turner & Woodruff (1948) found in two separate tests that emulsions were less effective than spray powders in controlling potato flea beetles. Yield following use of spray powders varied from slightly to substantially higher than when emulsions were used. These results brought into question the relative effectiveness of these two formulations for control of flea beetles.

Wilson & Sleesman (1946) tested four DDT emulsions on potatoes and found that one of them injured the foliage and reduced yield. Furthermore, none of the emulsions produced as high a yield as high concentrations of spray powder. Bronson & Smith (1946) reported three cases in which plants sprayed with spray powder outyielded those treated with emulsions, in spite of greatly improved aphid control with emulsions. In two cases emulsion-sprayed plants outyielded the others.

The yield of potatoes sprayed with chemicals is the result of two possible factors, soil fertility and virility of seed being equal (Horsfall & Turner 1943). Control of the pests tends to increase the yield and if the chemical has absolutely no effect on the physiology of the plant, better control with higher dosages should produce higher yield. If, on the other hand, the chemical is injurious to the plant, increasing dosage also results in a larger amount of injury and tends to reduce the yield. On the surface the differences in yields obtained by different workers could well be attributed to chemical injury to plants.

This phase of the investigation is concerned with two factors: (1) a study of the

Table 1.—Phytotoxicity of DDT solvents to potato foliage.

Material	Concentration of Emulsion	Injury After Application 1	2	3
Petroleum derivatives				
PD 544A[1]	2.0%	Severe	—	—
	1.0	Severe		
	.5	Severe		
PD 544B[1]	2.0	None	Slight	Slight
	1.0	None	None	None
	.5	None	None	None
PD 544C[1]	2.0	None	None	None
	1.0	None	None	None
	.5	None	None	None
PD 544D[1]	2.0	Severe	—	—
	1.0	Severe		
	.5	Severe		
TS 28[2]	2.0	None	None	None
	1.0	None	None	None
	.5	None	None	None
E 407[2]	2.0	None	None	None
	1.0	None	None	None
	.5	None	None	None
S 1547[3]	2.0	None	None	None
	1.0	None	None	None
	.5	None	None	None
Other derivatives[4]				
	2.0	None	Slight	—
	1.0	None	Slight	—
	.5	None	None	
Mixed alkyl ethers of beta naphthol[5]	2.0	Moderate		
	1.0	Slight		
	.5	Very slight		
Xylene	2.0	None	None	None
	1.0	None	None	None
	.5	None	None	None

[1] Obtained from Socony-Vacuum Oil Co., Inc.
[2] Obtained from Shell Oil Co., Inc.
[3] Obtained from Sun Oil Co.
[4] Obtained from Velsicol Corp.
[5] Obtained from Naugatuck Chemical Laboratories of U. S. Rubber Co.

possible injury by DDT emulsions to potatoes and (2) the relative effectiveness of emulsions and spray powders in controlling flea beetles.

TOXICITY OF SOLVENTS TO POTATO PLANTS.—The phytotoxicity of a group of solvents to potato foliage was determined by spraying emulsions on potato plants. In order to eliminate the possible injury of different emulsifiers, the same one[1] was used in all cases. The standard formula for the emulsions was:

DDT	25 per cent
Emulsifier	2 per cent
Solvent	73 per cent

Three of the solvents, PD544A, PD544D and the naphthol derivative required 4 per cent of the emulsifier. Single plants randomized in three blocks were sprayed with 2 per cent, 1 per cent and 0.5 per cent of total emulsion in water, using a continuous hand sprayer. The high concentration of emulsion was used in order to accentuate the differences between materials. Three applications were made at weekly intervals starting June 20. The results of the test are given in table 1, and show no visible injury after three applications for four of the solvents, slight injury following two applications of two solvents and moderate to severe injury following one application of three solvents. Most of the solvents caused little visible damage at the lowest concentration, which was still in excess of the amounts usually applied to potatoes in the field. However, it must be assumed that materials which cause visible injury at high concentrations may also injure the plants at lower dosages, even though there are no burned spots on the leaves.

The differences observed in the phytotoxicity of these solvents might well account for differences in yield observed by the authorities cited above.

CONTROL OF POTATO FLEA BEETLES.—Two comparisons of the effect of the two types of formulation on control of the potato flea beetle and on yield were made in 1948. A series of three dosages of emulsion and four of spray powders was applied to 15-foot plots of Katahdin potatoes planted May 4. The plots were randomized in four blocks and sprayed as described by Woodruff & Turner (1947). Sprays were applied weekly from June 8 to July 26, inclusive. Damage by flea beetles was estimated from the middle row on June 21 for overwintering beetles and on July 20 for the summer generation, using the system described by Horsfall (1945). Results of the estimates for flea beetle damage by plots are given in table 2 and figure 1. The data show that in general the spray powder was more effective in controlling flea beetles than the emulsion. There was less difference between the two formulations on the overwintering generation than on the July brood.

Yields of the potatoes by plots are re-

[1] *Triton X-100.*

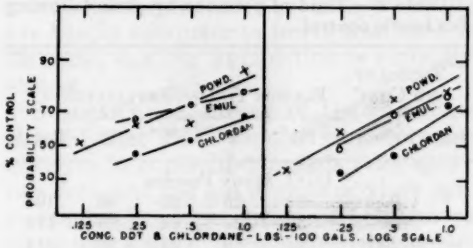

FIG. 1.—Dosage response curves for reduction in damage by the potato flea beetle. Results for June 21 at left, July 20 at right.

Table 2.—Reduction in damage by flea beetles by plots.

Figures indicate total score for damage to 10 plants

MATERIAL AND CONC. IN LBS./100 GALS.	TOTAL SCORE FOR 1	2	3	4	REPLICATE TOTAL	PER CENT REDUCTION IN DAMAGE
June 21						
DDT Spray Powder[1]						
1.0	6	2	4	3	15	87.2
0.5	15	16	6	5	42	63.8
0.25	15	12	8	8	43	63.1
0.125	15	14	16	12	57	51.7
DDT Emulsion[2]						
1.0	8	7	3	6	24	79.3
0.5	14	8	3	6	31	72.4
0.25	15	10	9	7	41	65.5
Chlordan Spray Powder						
1.0	14	11	9	4	38	67.2
0.5	18	10	11	15	54	53.4
0.25	25	10	20	10	65	44.4
No treatment						
—	29	29	32	25	175	—
July 20						
DDT Spray Powder						
1.0	2	5	3	4	14	91.1
0.5	5	4	3	5	17	89.4
0.25	8	6	7	14	35	77.9
0.125	10	22	11	25	68	56.9
DDT Emulsion						
1.0	4	3	3	5	15	90.6
0.5	7	5	7	6	25	84.3
0.25	18	10	7	13	48	69.6
Chlordan Spray Powder						
1.0	3	3	9	5	20	87.3
0.5	18	16	13	8	55	65.3
0.25	22	15	13	20	70	55.6
No treatment						
—	39	41	39	39	158	—

[1] Laboratory preparation, 50 per cent Technical DDT, 50 per cent Continental Clay, micropulverized.
[2] Commercial product, 34 per cent DDT, Pennsylvania Salt Co.

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Table 3.—Yield of potatoes by plots following flea beetle control.

Toxicant and Conc.	Pounds Yield—Replicate				
Lbs./100 gals.	1	2	3	3	Total
DDT Spray Powder					
1.0	22	26	30	26	104
0.5	32	29	22	29	112
0.25	25	26	24	36	111
0.125	28	37	23	30	118
DDT Emulsion					
1.0	27	24	29	30	110
0.5	26	25	32	26	109
0.25	29	25	29	31	114
Chlordan Spray Powder					
1.0	25	25	27	39	116
0.5	28	26	36	29	119
0.25	44	31	27	24	126
No treatment					
—	24	30	24	26	104

corded in table 3. As is usually the case the yields bear little relationship to the control of flea beetles. The yield from the emulsion plots was about the same as from those sprayed with powder.

The second test was a large scale field test applied in a commercial planting by means of a tractor-borne 10-row sprayer. The plots were arranged in a 4 by 4 latin square and were 10 rows wide and 150 feet long. Sprays were applied weekly from June 15 to August 30. Throughout the test it was obvious that the spray powder (2 lbs. 50 per cent/100 gals.) was providing better control of flea beetles than 1 quart of 30 per cent DDT emulsion in 100 gallons. About the middle of July, aphids were more abundant in the spray powder plots and a single treatment of emulsion was substituted for the spray powder. By August 15 aphids were so abundant in both series of plots that nicotine sulfate was added in two treatments. This controlled the aphids effectively.

Yield was obtained by weighing the potatoes dug from two rows of each plot, and by measuring by volume the crops from six additional rows. Results by plots are summarized in table 4. In all cases the crop was larger on plots sprayed with powder. It must be pointed out that the emulsion used in the field test was a different product than the one used in the plot tests described above.

Although the evidence is by no means

Table 4.—Yields of potatoes following treatment with DDT spray powder and emulsion.

Large-scale field test

Material	Yield—Lbs./300 Ft. Row Replicate 1	2	3	4	Total
Bordeaux Mixture 8–4–100 DDT Spray Powder 2 Lbs.—100 gals.	410	431	379	356	1576
Bordeaux Mixture 8–4–100 DDT Emulsion 1 Qt.—100 gals.	369	328	363	318	1378
	Yield—half-bushels—1200 ft. Row				
Spray Powder	64	57	52	47	220
Emulsion	57	51	47	44	199

Differences are significant by analysis of variance using also two fungicide tests not reported here.

overwhelming, it appears that spray powders usually provided better control of flea beetles than emulsions. Likewise some emulsions seem to produce a lower yield of tubers than spray powders. It would seem advisable to use spray powders for control of flea beetles and emulsions for control of aphids in order to obtain the best

Table 5.—Yields of potatoes following treatment with DDT and chlordan spray powders.

Large-scale field test

Material	Yield—Lbs./360 Ft. of Row Replicate 1	2	3	4	Total
Bordeaux Mixture 8–4–100 DDT Spray Powder 2 lbs.—100 gals.	555	456	397	353	1761
Bordeaux Mixture 8–4–100 Chlordan Spray Powder 2 lbs.—100 gals.	635	508	288	504	1935
	Yield—half bushels—1440 feet Row				
DDT	61	55	41	36	193
Chlordan	65	58	40	47	210

Differences are significant by analysis of variance using also two fungicides not reported here.

protection of the plants and the highest yield.

CHLORDAN FOR CONTROL OF FLEA BEETLES.—Kulash (1947) reported that chlordan was equal to DDT for control of the Colorado potato beetle. Turner & Woodruff (1948) found that chlordan was somewhat less effective than DDT for control of flea beetles but that the yield from chlordan treated plants seemed to equal the yield from plants sprayed with DDT. Two series of tests of chlordan spray powder were made, a test of dosages in small plots, and a large-scale field test. Results of the plot test have been given in tables 2 and 3. Control of flea beetles was again substantially less when chlordan was used than when DDT was the toxicant. However, as in the previous test, the yield of tubers was excellent.

The large-scale field test was carried out in the same manner as described above, but on a different farm. Observation of the plots showed that chlordan provided less control of flea beetles but somewhat better aphid control than DDT. Yields have been summarized in table 5. As was the case in the plot tests, the yield was much better than expected on the basis of insect control and was significantly higher than the yield following use of DDT. The apparently anomalous situation could easily follow if DDT caused some injury to the plant and chlordan was much less injurious. The data available are hardly adequate to prove that such is the case, but the implication is certainly strong.

SUMMARY.—A survey of the literature showed that DDT emulsions were more effective in controlling aphids than spray powders, but did not always produce correspondingly high yields. Furthermore there was some evidence that spray powders were more effective in controlling flea beetles.

Tests of phytotoxicity of solvents for use in making DDT emulsions showed substantial differences among the materials used.

Dosage tests in small plots and a large-scale field trial demonstrated that emulsions were less effective in controlling flea beetles than spray powders. Yields on small plots were about the same but in the field trial spray powders produced a significantly higher yield.

These facts indicate the desirability of using spray powders for control of flea beetles and emulsions for aphids.

Chlordan was less effective than DDT in controlling flea beetles but produced as good yields as DDT in small plots and significantly better yields in a field trial. Such a situation would result if DDT were injurious to potato plants and chlordan less so.

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Some Physiological Relationships of the Female European Corn Borer Moth in Controlled Environments[1]

A. M. VANCE, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

The European corn borer, *Pyrausta nubilalis* (Hbn.), like many other phytophagous insects, is very sensitive to temperature and humidity. This sensitivity was recognized early in the investigations of the species. As a result considerable emphasis was placed on a study of the ecology of the insect both in foreign countries where it had existed for many years and in the United States. For example, Babcock & Vance (1929) and Vance (1942) tried to associate annual fluctuations of area-wide corn borer abundance in the field with different meteorological conditions. Although much useful information was obtained from such work the results were not always so clear-cut and conclusive as desired, because of the difficulty of evaluating adequately the numerous interrelated influences always present in the field.

The study of individuals of the insect under controlled laboratory conditions was an attempt, therefore, to limit the number of factors affecting its physiological reactions and to determine, if possible, the real effects of some of the most important attributes of particular environments. It was the hope of the writer that these studies might throw some light on the various responses of the female moth, especially in relation to oviposition. The observations were not extensive; the number of temperature and humidity combinations that could be studied are many, and consideration might well be given to similar investigations of all stages of the corn borer. However, some of the results herein presented may be applicable to certain lines of research on the corn borer and may stimulate researchers to pursue similar laboratory studies on the physiological reactions of other insects.

METHODS.—The method of humidity control used in the experiments was based on the work of Buxton & Mellanby (1934), whereby potassium hydroxide solutions of certain specific gravities provided the required relative humidities within closed glass jars. The type of jar, and of cage inside it, used by the present author, although somewhat different, embodied the principles that they have described. The use of potassium hydroxide solutions of different concentrations to obtain required humidities is simpler and safer than the handling of saturated solutions of a number of different chemicals, as practiced by many workers.

Constant relative humidities of 96, 90, 50, 20, and 5 per cent were maintained within wide-mouthed pint glass jars having glass tops which could be made tight by means of jar rubbers and metal clamps. About 40 cc. of either water or a potassium hydroxide solution of known specific gravity (as determined with a hydrometer) was placed in the bottom of each jar. At the temperatures used (70°, 80°, 85°, and 90° F.), the relative humidity within a jar containing water was at or above 96 per cent, and that within a jar holding a potassium hydroxide solution was fixed by the specific gravity of the solution introduced.

A small moth cage was placed a little above the liquid in the jar on a 3-legged support made of fused-glass tubing. The moth cage itself consisted of an upright piece of tube[2] 0.125 inch in wall thickness, 2.75 inches in height, and 2 inches in inside diameter. The bottom of the cage was a disk of 20-mesh copper wire screen cemented to the lower end of the tubing. A similar screen disk was used for the top of the cage and held in place with two No. 3 wire paper clips. The inside wall of the cage was lined with waxed paper, which served as an ovipositing surface for the corn borer moth confined therein. Five of the glass jars containing their caged moths were placed in a wooden tray for ease in handling. This system of closed-space environment made it possible to keep a number of the test insects at a given temperature but under different known moisture conditions. Several times during the experiment and at the end the relative humidity within individual jars was checked by means of a dew-point apparatus fitted through a

[1] The work herein discussed was done from 1939 to 1942 at the European corn borer laboratory at Toledo, Ohio, under the direction of W. A. Baker. Wm. G. Bradley, now in charge of European corn borer research, reviewed the manuscript and H. R. Painter made the photographs.

[2] *Lucite.*

hole cut in a glass jar top. It was found to vary insignificantly from that at the start of the experiment.

The moths used in the experiments were obtained by putting corn borer pupae into a pint-size cylindrical cardboard container. The female and male moths that emerged from them during a 24-hour period were allowed to mate. (A lone pair of moths will seldom mate, the presence of a number of individuals seemingly being necessary to encourage attraction of the sexes.) One female moth that had been so exposed to mating was introduced into each cage. If she failed to deposit fertile eggs within the first 2 days of observation, she was considered to be unmated and was discarded. The cages were examined daily, the strips of waxed paper containing corn borer egg masses removed, and the masses and eggs counted. Fresh waxed paper was put into the cages, and water sprayed on it with a hand atomizer for the moths to drink. After the moths had sufficient opportunity to drink, they were removed to dry cages and returned in them to their respective jars. Care was taken not to keep the jars uncovered any longer than necessary during the operation.

In the determination of the dry weight and water content of female corn borer adults, the insects were weighed individually while alive with a precision balance. The specimens were then dried to a constant weight at 180° F., and reweighed. A short tube of thin cellophane was substituted for the weighing pan on the beam hook of the balance, and the proper adjustment made to compensate for the slightly increased weight of the tube over the pan. The tube was 3.5 inches long, 1 inch in diameter, open at the bottom end, and sealed flat across the top, where a small hole was cut to permit its easy attachment to the beam hook. The tube was placed over a moth in her oviposition cage and manipulated so that she crawled up inside sufficiently to gain a foothold. It was then possible to hang the tube containing the clinging moth on the hook of the balance for weighing. Subsequently, the tube with the moth was removed and a slight jolt given it to dislodge the moth and send her back into her cage.

WATER CONTENT AND DRY WEIGHT OF FEMALE MOTH.—Thirteen female moths of the corn borer were weighed individually, when alive and after desiccation, to determine their water content and the relation between their live and dry weights. The insects were collected near Toledo, Ohio, in the late spring of 1942 and weighed immediately. The data are presented in table 1.

In this test the water content of the moths averaged 50.7 per cent of the live weight. A direct relationship was found between the live and dry weights. The proportion of dry to live weight was not appreciably affected by differences in the initial live weights. As shown in table 5, the average number of eggs laid varied directly and in close relationship with the initial weight of the moths, although several of the weight classes should preferably have contained more individuals to strengthen the value of the figures.

Table 1.—Live and dry weights and water content of female moths of the European corn borer, Toledo, Ohio, 1942.

Moth No.	Live Weight in Milligrams	Dry Weight in Milligrams	Per Cent Water Content
1	79.7	40.5	49.2
2	72.8	38.5	47.1
3	67.8	32.6	51.9
4	64.4	30.3	53.0
5	63.2	29.3	53.6
6	62.5	30.4	51.3
7	60.8	29.7	51.2
8	60.7	32.3	46.8
9	60.6	31.5	48.0
10	58.6	28.4	51.5
11	53.5	25.5	52.3
12	53.0	25.3	52.3
13	47.9	23.7	50.5
Mean	62.0	30.6	50.7

The fat content is no doubt of extreme importance in the corn borer, as in a number of other insects. Norris (1934) stated that, "since adult Lepidoptera take no food containing nitrogen (nectar only containing very small traces of nitrogen) they depend for the ripening of their genital products on the nitrogenous substances stored in the fat-body," and that the fecundity of the moth *Ephestia cautella* Wlk. was limited by the quantity of "egg-developing substance" in the fat body. The same seems to be true of the European corn borer. The heaviest female would be expected to possess the largest fat reserve and thus be capable of producing and depositing the greatest number

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of eggs. It is probable also that an association exists between the fat content of the corn borer larva and that of the adult insect, and it is likely that the former is directly related to the nutrition of the feeding borer. Thus, the most satisfactory oviposition should result from good-sized moths with adequate fat reserves, which in turn have been derived from large, well-nourished larvae.

FOOD AND WATER REQUIREMENTS OF FEMALE MOTH.—In addition to satisfactory environmental conditions, the female corn borer moth requires water to drink. Without this liquid her life is measurably shortened. Little or no evidence exists, however, to indicate that the moth habitually feeds on nectar in the field or that sugar in any form is essential to the proper functioning of her life processes.

Huber *et al.* (1928) reported on experiments conducted under varying temperatures to determine the effect of different grossly controlled conditions of humidity on the longevity and egg production of female corn borer moths. These experiments indicated that the higher humidities were more favorable for egg deposition, and that conditions best suited to oviposition were also conducive to longer life. Although no statement was made to that effect, the reported data leave the impression that, in the experiments where humidity was provided, the female moths had access to water for drinking, whereas in experiments where humidity was not increased, the moths were unable to obtain water. It is possible that the greater longevity and significantly increased egg production of the moths in wet cages, as compared with those in dry cages, were due principally to the availability of water for drinking rather than to high humidity conditions alone. Kozhantshikov (1938) reported experiments on feeding the female corn borer moth with different solutions of glucose, and found that an increase in sugar concentration of the food increased the longevity and fecundity of the moths and that the nutrition of sugar affected the fat reserves. However, his data indicate that he worked with a very limited number of test insects, and the differences shown are not striking. He gave the water content of freshly emerged moths as 60.9 per cent and considered the moth to be rich in fat (14.5 per cent of live weight). Only a small amount of sugar (0.2 per cent of live weight) was found in the moths which he tested.

Norris (1934) discussed at some length the feeding habits and requirements of adult Lepidoptera and quoted the results obtained by different workers on various species of the order. She divided the food requirements of the order into the following four classes:

"(i) Species which require neither sugar nor water and cannot take them owing to reduction of the mouth-parts.

(ii) Species which can take sugar and water (*i.e.*, mouth-parts quite normal), but which have no necessity for it.

(iii) Species which require water but not sugar.

(iv) Species which require both water and sugar."

Apparently the corn borer moth belongs to the third class. It is probable that the adult of this species does not possess the protease and invertase necessary for the digestion of proteins and cane sugars, respectively, or at least has retained only such small quantities of these enzymes that they are of little biological value to the species.

In one experiment ovipositing females were kept at a temperature of 80° F. and a relative humidity of less than 5 per cent, and the weight of the individual moths was determined before and immediately after they had been drinking. The data are given in table 2. Such a desiccating environment naturally shortened the lives of the moths. The weight of water taken by a moth at one drinking was great in proportion to her body weight. The average daily consumption of the four individuals during their average lifetime of 5 days was 8.7 milligrams, the maximum 14.9, and the minimum 2.8 milligrams. The average daily increase in body weight immediately after one drinking amounted to 26.4 per cent. The maximum gain, 48.3 per cent, was made by the smallest female under observation, but the average lifetime gain of this individual did not differ appreciably from that of any other moth. In this experiment, at least, the weight of the moth did not influence the increase in body weight caused by the drinking of water. However, the heaviest moth drank the most water at one time. It should be noted that the moths actually lost weight from day to day. Similar data for moths kept under more

Table 2.—Increase in weight due to the drinking of water by four female moths of the European corn borer kept at a temperature of 80° F. and a relative humidity of less than 5 per cent.

Day	Weight of Moth in Milligrams		Per Cent Increase in Weight
	Before Drinking	After Drinking	
	Moth No. 1		
1st	69.3	80.5	16.2
2nd	56.0	70.9	26.6
3rd	54.3	68.7	26.5
4th	50.4	62.3	23.6
5th	42.8	55.5	29.7
Mean	—	—	24.5
	Moth No. 2		
1st	39.6	44.8	13.1
2nd	30.4	37.8	24.3
3rd	27.3	35.7	30.8
4th	25.0	32.4	29.6
5th	24.4	28.3	16.0
Mean	—	—	22.8
	Moth No. 3		
1st	37.0	50.8	37.3
2nd	35.2	48.8	38.6
3rd	31.9	40.4	26.6
4th	24.0	30.0	25.0
Mean	—	—	31.9
	Moth No. 4		
1st	32.1	36.1	12.5
2nd	23.0	29.1	26.5
3rd	22.4	29.2	30.4
4th	20.1	26.1	29.8
5th	20.3	30.1	48.3
6th	17.2	20.0	16.3
Mean	—	—	27.3

favorable conditions would be of interest.

EFFECTS OF DIFFERENT TEMPERATURE AND HUMIDITY CONDITIONS ON OVIPOSITING MOTH.—Detailed observations were made of individual mated and ovipositing moths of the corn borer to determine the effects of several different combinations of temperature and humidity on their longevity, oviposition, and loss of weight. Temperatures of 70°, 80°, 85°, and 90° F., and relative humidities of 5, 20, 50, 90, and 96 per cent were used. Summaries of the data are given in tables 3 to 7.

The most favorable combination was a temperature of 85° F. and a relative humidity of 96 per cent (Table 3), since the moths kept in this environment laid the most eggs and the largest egg masses, during a life span of intermediate length. A temperature of 80° with high relative humidity was generally favorable for the ovipositing moths. Lower humidities progressively reduced egg deposition, size of egg masses, and life span. Lower temperatures also reduced egg deposition and size of egg masses, even though they increased length of life. A temperature of 90° definitely reduced both egg deposition and longevity. Extremely low humidity greatly reduced length of life, number of eggs laid, and size of egg masses.

A temperature of 80° F., at which satisfactory oviposition was procured in the laboratory, is somewhat higher than that prevailing in the field at night during the normal oviposition period of the moths in nature. It would be desirable, therefore, to obtain data on the effect of different relative humidities at temperatures between 65° and 80°. However, the data procured at 80° do indicate that the European corn borer moth may be much less affected by atmospheric humidity than is commonly supposed, and it seems doubtful whether moths in the neighborhood of corn fields ordinarily have to endure a humidity low enough in itself to be very detrimental. They may, however, be seriously affected by heat and winds combined with a relatively dry atmosphere.

Infertility was low in all groups tested, although it was somewhat higher among the moths kept at 90° F., even with high relative humidity. Nevertheless, the production of infertile eggs was not common to all individuals under these conditions. More data are required before high temperature can be considered the cause of such infertility.

The temperature-humidity environment of the moths was also studied from the standpoint of saturation deficiency, which is a measure of the difference between the vapor pressure of water at a given humidity and temperature and that at the saturation point at the same temperature. Buxton (1931) pointed out that the physical law of saturation deficiency might govern the loss of water from an insect in much the same way that it affects the rate of evaporation of water from an open surface, and he proposed the use of certain data already accumulated to test his hypothesis. Earlier, Bacot & Martin (1924) observed that such a law was operat-

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Table 3.—Effects of different constant temperatures and humidities on longevity and oviposition of female moths of the European corn borer confined individually and given drinking water daily.

Temperature in °F.[1]	Per Cent Relative Humidity	Number of Moths	Longevity		Number of Eggs per Moth			Per Cent Infertile Eggs per Moth	Number of Fertile Eggs per Mass
			Days per Moth	Range of Days	Maximum	Minimum	Average Fertile		
70	96	21	15.9	8–26	1044	372	708	1.7	13.6
80	96	30	14.0	7–31	1107	250	758	1.2	13.0
	90	30	13.2	7–27	1086	176	663	1.2	14.1
	50	30	11.3	6–21	839	274	495	0.1	11.0
	20	30	11.1	4–18	906	154	505	0.1	8.0
	5	16	3.7	2– 7	356	25	136	0	7.6
85	96	22	10.8	5–19	1358	582	823	0.4	15.9
90	96	26	8.8	4–14	1239	122	533	5.7	13.4

[1] Varied within 2°.

ing in their experiments on the duration of life of the adult flea *Xenopsylla cheopis* (Rothschild).

Mellanby (1935) stated the saturation-deficiency law in a revised form, as it relates to insects, as follows:

"If individual insects of the same species, in identical morphological and physiological states, are exposed to atmospheres with different humidities, then the rates at which the insects lose water will be proportional to the saturation deficiency, provided that the saturation deficiency is not above a maximum figure which is peculiar to the species. From this it follows that when insects are killed by desiccation, the length of life of the insects will be inversely proportional to the saturation deficiency of the air."

He further gave two corollaries to the law—namely, "(1) If the rate of loss of water from different individual insects does not appear to be proportional to the saturation deficiency of the air, then their morphological and physiological states cannot be the same," and "(2) When insects are exposed to atmospheres of different humidity, if there appears to be no direct relation between the length of time which they survive and the saturation deficiency, then other lethal factors, besides desiccation, must be at work."

Attention should be given to the applicability of the saturation-deficiency law to any experiments with insects at different temperatures and humidities. Most of the data on the corn borer obtained in the writer's experiments were not of such nature or extent that the saturation-deficiency law could be profitably applied. However, in the four groups of females kept at 80° F. (Table 4), the average longevities at different relative humidities tended to be inversely proportional to

Table 4.—Further effects of different constant temperatures and humidities on female moths of the European corn borer confined individually and given drinking water daily.

Temperature °F.[1]	Per Cent Relative Humidity	Saturation Deficiency in Milligrams of Mercury	Number of Moths	Longevity per Moth in Days	Weight per Moth in Milligrams			Per Cent Loss of Initial Weight per Moth	Number of Fertile Eggs per Moth
					Initial	Loss per Day	Final[2]		
70	96	0.7	7	15.7	55.0	2.2	20.0	36.4	785
80	96	1.1	12	13.6	62.7	2.6	27.3	43.5	775
	90	2.7	10	12.7	64.8	3.0	26.1	40.3	762
	50	13.3	8	11.4	54.1	2.5	25.1	46.4	544
	20	21.3	10	11.2	62.5	3.1	27.6	44.2	663
85	96	1.2	10	10.0	62.9	3.2	30.6	48.6	808

[1] Varied within 2°.
[2] Taken on last day of life.

the saturation deficiencies of the environments. Neither the loss of initial weight per moth nor the loss of initial weight per moth per day was correlated with the measurements of saturation deficiencies. The comparative data given in table 4 are concerned only with those individuals which were weighed, and the numbers are therefore fewer than the totals on which the figures in table 3 are based.

RELATION BETWEEN WEIGHT AND LONGEVITY OF MOTH AND FECUNDITY.—In tests to determine the association between the initial weight of a moth and its egg production, moths were kept at temperatures of 70° to 85° F. and at relative humidities of 20 to 96 per cent. The moths were weighed on the first day after emergence and mating and prior to oviposition. The heaviest moths produced the greatest number of eggs and the lightest the smallest number, as shown in table 5.

Similar tests were made to determine the association between longevity of the moths and the number of eggs deposited. Except for two moths which lingered on for some time after the period of active oviposition, some such association existed. These data are given in table 6. The tests also indicated that length of life and of oviposition period were usually related to the vigor of the moths. Infertile eggs, when deposited by mated moths, were usually laid during the later part of the oviposition period. As a rule unmated corn borer moths laid relatively few eggs, often depositing them individually or in small irregular-sized masses. All such eggs were infertile.

TREND OF OVIPOSITION.—The greater portion of the egg complement of the moths was deposited during the first 10 days of life, even though the moths lived much longer. The percentages of eggs deposited during the first 10 days of life by moths kept under different conditions are shown in table 7. At 70° F. the rate of egg deposition was a little slower than at the higher temperatures. Other study of the original data showed that at 90°, where the rate was most accelerated, as many as 79.5 per cent of the eggs were laid during the first 5 days of life. Incidentally, the largest number of eggs laid on a single day by a moth during the course of the experiments was 330, on the fourth day of her life, at 85° and 96 per cent relative humidity; the total complement of this moth reached 912 eggs during a lifetime of 13 days.

In the determination of the trend of oviposition during the first 10 days of moth life, the available data for the experiments were combined, except those for moths kept at the low relative humidity of 5 per cent. The mean numbers of eggs deposited per day, beginning the second day of life, are illustrated by a fitted straight line (Fig. 1).

EFFECT OF SUDDEN CHANGES IN TEMPERATURE ON OVIPOSITION.—During the flight and oviposition period of European corn borer moths in June or July, when temperatures are generally favorable for activity, the temperature may suddenly turn cool and remain so for some days. Such drops in temperature cause a lessening of the activity of the adult female and a reduction or even cessation of oviposition. It has seemed possible that conditions of this type might leave a more or less permanent impression on the physiology of the moths, perhaps reducing their vigor, impairing their ability to oviposit, and shortening their lives, even though more favorable conditions might recur within their lifetimes.

Barber (1925), in a study of temperature effects on the female moth of the corn borer and her deposition of eggs in Massachusetts, stated that "even if the usual number of eggs develops in the

Table 5.—Association of initial weight of female moths of the European corn borer with fecundity.

	Number of Moths	Initial Weight of Moths in Milligrams		Number of Eggs per Moth
		Mean	Range	
	1	38.2	38	479
	10	47.8	39–50	579
	14	55.1	51–60	613
	32	64.2	61–70	701
	8	75.2	71–80	764
	1	86.0	86	1086
Total or Mean	66	61.1	38–86	704

Table 6.—Association of longevity of female moths of the European corn borer with fecundity.

	Number of Moths	Longevity in Days		Number of Eggs per Moth
		Mean	Range	
	14	5.5	4– 7	361
	116	11.5	8–15	674
	31	21.5	16–27	808
	2	30.5	30–31	635
Total or Mean	163	17.3	4–31	620

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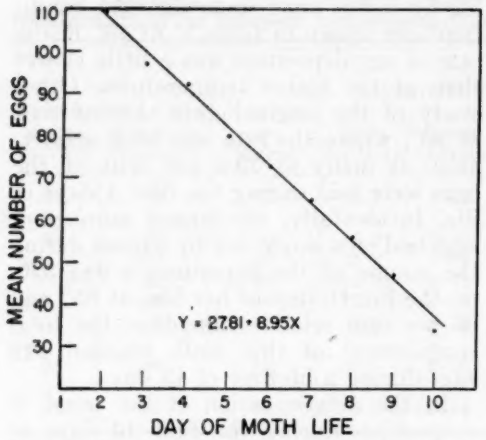

FIG. 1.—Fitted straight line to show trend of oviposition of European corn borer moths confined at seven favorable temperatures and humidities as expressed by the daily mean number of eggs deposited during the first 10 days of life. The points shown for the second to fifth days are based on data for 164 individuals; those for the sixth to tenth days are based on data for 97 individuals. No eggs were recorded for the first day of life.

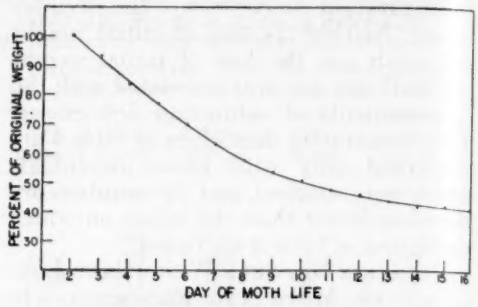

FIG. 2.—Curve showing loss of weight of ovipositing moths of European corn borer expressed as per cent of original weight. The averages used in determining the curve were based on the combined data for 6 moths kept at 70°, 12 at 80°, and 8 at 85° F., all at a relative humidity of 96 per cent.

ovaries of the insect, cool temperatures, by producing inactivity or stupor, may cause the insect to deposit only a portion of the total number of eggs she carries, and, should such conditions persist, she may die without complete oviposition." He found that a mean night temperature of 60° F. or less was usually accompanied by a considerably reduced egg production.

Huber *et al.* (1928) expressed a similar association between moth activity and temperature in Ohio, but intimated that eggs might sometimes be deposited on cool nights as a result of their accumulated development in the bodies of the females during temperatures favorable for their formation.

In New York, Hervey & Palm (1935) found that temperatures between 70° and 75° F. were most favorable for flight of the corn borer moth. Moth catches dropped off rather rapidly below 70°, and the activity of the insect was much retarded below a mean of 60°.

Stirrett (1938) said that in his experiments in Canada the lowest temperature at which moths were observed to fly was 56° F. and the highest was 87°. He stated that flight activity was greatest between 65° and 70°, as 67.2 per cent of all moths flew between these temperatures. The largest number of moths for any single temperature was observed at 70°, and 93.1 per cent of all moths flew between 60° and 76°. Stirrett went on to say that a lowering of the temperature from 65° inhibited flight very quickly, whereas an increase in temperature above 75° decreased flight more gradually.

The available data show, therefore, that temperatures below 60° F. discourage flight and egg deposition of the moth while those above that figure, up to a certain point at least, are more favorable for moth activity, with the optimum temperature in the field lying between 70° and 75°.

In order to obtain some data on the effects of sudden changes of temperature on the female corn borer moth, mated females were confined individually in small cages maintained at a relative humidity of approximately 96 per cent within closed glass jars and subjected to varied and alternating temperature conditions. Drinking water was available to the moths daily. The data obtained are presented in table 8 and for comparison the figures are given on moths used in

Table 7.—Eggs laid by moths of the European corn borer during the first 10 days of life.

TEMPERATURE IN °F.[1]	PER CENT RELATIVE HUMIDITY	NUMBER OF MOTHS	PER CENT EGGS LAID
70	96	21	89.1
80	96	12	95.3
	90	30	92.4
	50	30	94.0
	20	30	93.1
85	96	22	97.4
90	96	26	99.7

[1] Varied within 2°.

Table 8.—Effects of controlled temperature changes on oviposition of moths of the European corn borer.

Time and Temperature of Exposures, °F.	Number of Female Moths	Longevity in Days		Number of Eggs per Moth			Per Cent Eggs Infertile
		Mean	Maximum	Mean	Fertile	Maximum	
1 day at each of 85, 80, 75, 70, 60, 40, 60, 70, 75, 80, rest of life at 85	8	15.1	22	621	599	809	3.5
1 day at each of 85, 60, 85, 60, rest of life alternating	10	16.9	25	637	570	785	10.5
1 day at each of 85, 40, 85, 40, rest of life alternating	10	24.5	39	494	420	759	15.0
1 day at 85, 3 days at 40, rest of life at 85	8	16.8	30	549	457	769	16.8
1 day at 85, 2 days at 40, rest of life at 85	7	15.0	19	691	624	859	9.7
2 days at 85, 2 days at 40, rest of life at 85	3	15.3	21	649	647	807	0.3
2 days at 80, 4 days at 40, rest of life at 85	7	22.4	24	514	459	686	10.7
2 days at 80, 6 days at 40, rest of life at 80	7	21.3	25	489	456	733	6.7
3 days at 85, 4 days at 40, rest of life at 85	5	17.8	25	636	623	941	2.0
6 days at 40, rest of life at 85	2	22.5	29	579	535	636	7.6
Entire life at 85	22	10.8	19	826	823	1358	0.4
Entire life at 80	30	14.0	31	767	758	1107	1.2
Entire life at 70	21	15.9	26	720	708	1044	1.7
Total or mean for variable temperatures	67	18.8	39	586	539	778	8.3
Total or mean for constant temperatures	73	13.6	31	771	763	1170	1.1

other experiments which were kept continuously at certain favorable temperatures and humidities. In these tests both the longevity and fecundity of the female moths were affected less than expected by the exposure at different temperatures, even when the changes were sudden and extreme and when they were continued for a considerable period. The moths exposed to variable temperatures averaged about 5 days longer life than those kept at the constant temperatures of 85°, 80°, and 70° F.

In the experiment where eight moths were subjected daily to progressively lower temperatures and then returned gradually to the original temperature, eggs were deposited in the 1-day periods at 85°, 80°, 75°, and 70° F., but none at 60° or 40°, or back at 60°. On their return to 1 day at 70°, the moths resumed oviposition and continued laying eggs during their exposure for a day at 80° and during the rest of their lives at 85°, two of the individuals depositing eggs as late as the sixteenth day of life.

The 10 moths exposed to temperatures alternating daily between 85° and 60° F. deposited eggs readily at 85° and 5.6 per cent of their total production of fertile eggs at 60°. Only 5 of the moths oviposited at 60°, however, It is probable that the eggs were laid at 60° very soon after the jars containing the moths had been returned to that temperature and before the cold had permeated sufficiently to affect the moths already stimulated by their exposure at 85°. This idea is strengthened by the observation that the moths in this experiment were actually depositing eggs while being examined in a temperature of 80° in the incubator, after their exposure at 85° and just prior to their change to the 60° environment.

Ten individuals whose environment was alternated daily from 85° to 40° F. throughout life lived the longest of all the test insects, averaging 24.5 days. Under such conditions the moths laid an average of 420 fertile eggs. One individual of this lot lived 39 days and deposited 271 fertile eggs during the first 10 days of her life. Throughout the experiment the moths did not lay at 40° but did deposit eggs whenever placed in the more favorable temperatures of 70° and above.

When moths ovipositing normally for 1 to 3 days at 80° or 85° F. were exposed at 40° for periods of 2 to 6 days, egg laying ceased, and when returned to the higher temperatures, they resumed oviposition readily, deposited a normal quota of eggs, and lived a normal lifetime. When two females were exposed at 40° for 6 days immediately after mating and then at 85°, egg laying occurred on the first day

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at the higher temperature, normal quotas of eggs were laid, and longevity averaged 22.5 days.

Numbers of infertile eggs, from 0.3 to 16.8 per cent of the total, were laid late in life by the moths used in the variable-temperature experiments. The average egg infertility was 8.3 per cent for the 67 moths kept at variable temperatures compared with only 1.1 per cent for the 73 moths exposed to three constant temperatures. Of the former group 71.6 per cent deposited some infertile eggs, whereas of the latter group only 19.2 per cent laid infertile eggs. These data thus indicate that the sudden and variable changes did result in an increased infertility of the eggs, and it is possible that the exposures to low temperatures had some effect on the fertile eggs and the larvae hatching from them, although these possibilities were not investigated.

It is suggested by these experiments that exposure of mated and ovipositing female corn borer moths to temperatures low enough to inhibit oviposition (40° to 60° F.) for several days at a time, provided they are living in a moist environment, may not be particularly detrimental if the moths are later exposed to higher and more optimum temperatures for egg deposition. Serious effects on the ovipositing moth of prolonged cool spells in the field may be due, not to the low temperature itself, but to the extended exposure of the insect to accompanying adverse factors such as driving winds, rain, or predators.

Experiments were not conducted with male moths to determine the effects of low temperatures on them. It may be that the male is more susceptible than the female to sudden changes in temperature or to low temperatures and that reproduction in nature under such conditions is indirectly affected by a reduction of the vitality, mating ability, and longevity of the males. It is also possible that low temperatures have some adverse effect on the mating responses of the females. Much could be done to clear up these uncertainties by conducting additional experiments with larger samples and other temperatures, humidities, and periods of exposure.

LOSS OF WEIGHT OF OVIPOSITING MOTH.—The fertilized and ovipositing female moth of the European corn borer loses weight daily when kept in a very moist environment (96 per cent relative humidity) at temperatures of 70°, 80°, and 85° F., and when provided daily with drinking water. The data supporting this conclusion are presented graphically in figure 2. In the experiments on loss of weight of ovipositing moths, little effect of the three different temperatures was observed, although it is probable that more data would have shown an increase in the rate of loss in weight with higher temperatures and an acceleration in metabolism and oviposition. It is believed that the loss of weight was due to three factors—(1) deposition of eggs, (2) a depletion of the fat reserves, and (3) a general breaking down of body tissues or catabolism with no restorative action or anabolism due to intake of food. Part of the steady loss of body weight was compensated for by the daily drinking of water, without which the rate of loss undoubtedly would have been considerably increased and the life of the moth definitely shortened. It would be of interest to determine the actual intake of water by moths kept in controlled environments and its relation to the loss of body weight due to (1) egg deposition and (2) the combined effect of fat utilization and general metabolic activity within the organism.

SUMMARY.—Experiments were conducted to determine the effects of different combinations of temperature and relative humidity on the female moth of the European corn borer, *Pyrausta nubilalis* (Hbn.). Temperature was controlled in small closed jars within which the humidity was regulated by means of water or potassium hydroxide solutions of varying specific gravities.

The average water content of 13 female corn borer moths was 50.7 per cent, and this percentage did not vary materially among moths differing in initial live weights. The heaviest moths deposited the greatest numbers of eggs.

The corn borer moth requires water to drink. It is believed that she does not possess, at least in quantity, the enzymes necessary for the digestion of proteins and cane sugars. Four female moths kept at 80° F. and a relative humidity of only 5 per cent weighed an average of 26.4 per cent more each day immediately after drinking water. However, at each subsequent weighing prior to drinking the

moths weighed less than at the same time on the previous day. The heaviest female drank the greatest quantity of water at one time.

A temperature of 85° F. and a relative humidity of 96 per cent were found to be optimum for the ovipositing corn borer moth. In this environment 22 females during their lifetime deposited an average of 823 eggs. The mean longevity of this group was 10.8 days. Moths kept at 70° and 80° and a relative humidity of 96 per cent deposited 708 and 758 eggs, and lived 15.9 and 14 days, respectively. Moths kept at 80° and relative humidities of 50 and 20 per cent lived 11.3 and 11.1 days, and averaged as high as 495 and 505 eggs per female, respectively. However, at 80° with the relative humidity only 5 per cent the mean number of eggs per moth dropped to 136 and the longevity to 3.7 days. Moths kept at 80° and a relative humidity of 90 per cent deposited a mean of 663 eggs per moth and lived 13.2 days, whereas those kept at 90° and 96 per cent relative humidity laid a mean of 533 eggs per moth and lived 8.8 days. These data indicate that humidity in itself seldom affects oviposition under usual field conditions.

Infertile eggs generally appeared late in the life of the ovipositing moth. The percentage of infertile eggs was less than 1.7 except at a temperature of 90° F., when it reached 5.7.

At 80° F. the average longevities of four groups of moths kept at different relative humidities were inversely proportional to the saturation deficiencies of the environments.

In most tests more than 90 per cent of the egg complement of a moth was deposited during the first 10 days of her life. The largest number of eggs laid by a moth in 1 day during the experiments was 330, at 85° F. and 96 per cent relative humidity. There was a rapid downward trend of oviposition from the second through the tenth day of a moth's life.

Sudden changes in temperature, such as daily shifts from 80° to 40° F. and back, all at 96 per cent relative humidity, had surprisingly little adverse effect on the total egg deposition and longevity of the moths. Oviposition ceased at 40° and at 60°, but was immediately resumed at 70°, 80°, and 85°. Infertility of eggs at the variable temperatures (8.3 per cent) averaged somewhat higher and was more frequent than at the constant temperatures (1.1 per cent). The detrimental effects of prolonged cool spells in the field may be due not to the low temperature itself but to the continued exposure of the moths to other factors such as driving winds, rain, predators, etc., or possibly to some physiological influence on the mating responses of the moths.

Weight was lost daily by the ovipositing moth when kept in a moist environment (96 per cent relative humidity) at temperatures of 70°, 80°, and 85° F., and provided daily with drinking water. It is believed that the loss of weight was due to three factors—(1) deposition of eggs, (2) a depletion of the fat reserves, and (3) a general breaking down of body tissues or catabolism with no restorative action or anabolism due to intake of food.

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Cotton Insect Control with New Organic Insecticides in Mexico

IGNACIO MORENO,[1] *In Charge, Agricultural Section, Du Pont, S. A., Mexico*

For several years the farmers in the La Laguna District of Mexico, one of the principal cotton and wheat-growing areas in that Country, have been trying to raise annually the two crops on the same land. Up to the present, cotton planted soon after the harvest of the previous wheat crop has produced good stands of seedlings with fast growth during the warm summer weather, the production of fruiting forms being satisfactory.

However, the planting being done so late in June, whereas regular cotton planting in the La Laguna District is done in March and April, those fields served as traps for cotton insect pests which became so abundant that no cotton could be picked. Experiments conducted during 1946 and 1947 in Mexico by the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine, Division of Cotton Insect Investigations, for the control of the pink bollworm of cotton, *Pectinophora gossypiella* (Saund.), with new organic insecticides has created considerable interest among the Mexican farmers.

An outstanding farmer, Mr. L. J. Garza, solicited us to test these insecticides for the control of cotton insects in late-planted cotton as a practical demonstration to the farmers of the effectiveness of insecticides for the control of cotton insects in general.

The field chosen for the demonstration consisted of approximately 10 acres of which 7.5 acres were staked out to be treated with whatever insecticide or mixture of insecticides was needed for control of insect pests. Two and a half acres were left untreated as a check. A total of 11 applications were made in the treated plot from August 18 to October 26, 1948. Although at the beginning of the work it had been planned to use throughout the season a mixture containing 2 per cent gamma isomer of benzene hexachloride and 10 per cent DDT,[2] special conditions made it necessary to make changes intercalating some applications of a 6 per cent gamma isomer of benzene hexachloride dust,[3] as follows: 4 applications of the mixture; 3 applications of the 6 per cent γ benzene hexachloride dust and 4 additional applications of the mixture.

As soon as the wheat crop was harvested from that field, the land was properly prepared and the cotton seed planted on June 24, 1948. The most damaging cotton insects in the Laguna District are the pink bollworm, the bollworm, *Heliothis armigera* Hbn., a stink bug *Chlorochroa* sp., the cotton aphid, *Aphis gossypii* Glov., and the boll weevil, *Anthonomus grandis* Boh. Field inspections were started soon after the cotton seedlings reached the four-leaf stage mainly for the purpose of finding infestations, if any, of the red spider mite, *Tetranychus telarius* L., the cotton flea hopper, *Psallus seriatus* Reut., and aphids. The latter was the only one present at that time although in such small numbers that it did not warrant the expense of insecticides for its control. It was not until August 11, 1948, that the cotton squares on the plants were large enough to be examined. A sample of 100 of the squares was collected at random along the center rows from each of the treated and untreated fields at weekly intervals and examined for boll weevil feeding or egg punctures and bollworm damage and opened for first instar larvae of the pink bollworm. The aphid infesta-

[1] Fernando Huerta and Mateo Nalda, field inspectors of Du Pont, S. A., assisted in the work reported in this paper.

[2] *Aprocon 2-10*, prepared locally in Du Pont, S. A.'s own mixing plant at Torreon, Coah., Mexico.

[3] *Lezone 50*, manufactured by E. I. du Pont de Nemours and Co., Inc.

Table 1.—Summary of cotton square and green cotton boll examinations for various cotton insects in the demonstration plots, along with dates of inspections and dates of application of insecticides.

TREATMENTS	2% BENZENE HEXACHLORIDE—DDT MIXTURE					6% GAMMA BENZENE HEXACHLORIDE DUST			2% BENZENE HEXACHLORIDE—10% DDT MIXTURE			
Dates of Applications	8-18	8-25	9-1	9-18		9-23	9-28	10-3	10-8	10-15	10-21	10-26
Dates of Inspections												
	8-11	8-17	8-24	8-31		9-17	9-27	10-2	10-6	10-11	10-30	10-8
INSECT	INFESTED SQUARES					INFESTED BOLLS						
	per cent					*per cent*						
Boll weevil												
Treated	8	20	9	17	R	91	50	42	19	17	9	32	—
Untreated	11	32	79	90	A	99	100	—	—	—	—	—	—
Pink Bollworm					I								
Treated	1	9	8	6	N	4	7	5	33	35	25	22	—
Untreated	1	14	18	7	S	—	—	—	—	—	—	—	—
Aphids													
Treated	L	O	O	P		O	P	O	O	O	O	O	—
Untreated	L	H	H	H		H	H	H	H	H	L	L	—

L—Light; P—Present; H—Heavy.

tion was estimated only. Beginning on September 27, 1948, cotton square collections were discontinued and green cotton bolls collected instead, 100 per week, from the center rows of each plot and examined for boll weevil, pink bollworm, bollworm and stink bug damage. Table 1 is a summary of the results of those inspections and examinations. Since the few bollworm larvae in the untreated plot or stink bugs in the treated plot had not damaged the bolls, these two pests are omitted from this table.

As soon as 20 per cent of the cotton squares were found punctured by the boll weevil, applications of the benzene hexachloride-DDT mixture at the rate of 15 pounds per acre were started and continued at 7-day intervals. For these first applications, a horse-drawn, 5-row Messinger dusting machine was used, obtaining a good coverage of the plant foliage. All the dustings were made early in the morning. It will be noticed that on the treated plot the boll weevil infestation was held in check until August 31, while in the check plot it steadily increased. However, during early September, a wet spell with heavy rains prevented insecticidal applications.

When the soil became dry enough and further cotton square collections could be made, the boll weevil infestation in the treated plot had reached a point where it was deemed necessary to use stronger control measures against this particular pest. Since the pink bollworm and the bollworm infestations were so light DDT was omitted at that time and applications of 6 per cent γ-benzene hexachloride dust were started at the same rate as with the mixture, but at 5-day intervals instead of the 7-day schedule planned at the beginning of the work. After the rains plant growth was so abundant that for the next applications of insecticides it was necessary to do airplane dusting[1] in order to avoid damage to the crop resulting from the horses or the wheels of the dusting machine passing through the rows. After the first application of the DDT-benzene hexachloride mixture the aphid infestation practically disappeared from the treated plot, while in the check plot its development was so great that it stunted the plant growth, the leaves curled down and became shiny with honey-dew, remaining so throughout the season, with a natural and heavy damage to the crop.

Fifty per cent of the bolls in the treated plot were found to be infested with young boll weevil larvae during the first green

[1] The author wishes to acknowledge his indebtedness to Mr. and Mrs. F. Cuellar who kindly loaned one of their dusting airplanes for this demonstration.

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cotton boll examination, while only 7 per cent of the same sample was infested with pink bollworm larvae. After the third application of a 6 per cent γ-benzene hexachloride dust, the boll weevil infestation was lowered to 19 per cent, while the percentage of bolls infested with pink bollworm increased to 33. Consequently, applications of the benzene hexachloride-DDT mixture were renewed at 7-day intervals. The boll weevil infestation continued decreasing while the pink bollworm infestation was held in check at about the same level for the rest of the season, with an average of 1.94 larvae per infested boll in the last examination. On the other hand, although green cotton bolls were also collected and examined from the check plot, no infestation counts could be made, since from the beginning all the bolls were so badly damaged by insects that it was impossible to determine the percentage infested by the boll weevil or pink bollworm or the percentage damaged by the stink bug, of which a few specimens were feeding on the outside of the bolls.

During the first fortnight of November, 1948, a frost killed all the leaves, young bolls and terminal buds of the plants. On November 16, cotton was picked from the treated plot for the first time. Because of the writer's absence, no careful records of the yields were taken. However, in the untreated plot so few cotton bolls opened, the cotton in those bolls being so poor in quality that it was not considered worth while to pick it, and even the cotton pickers refused to go into that plot to work. In the treated plot an average of 880 pounds of seed cotton was picked per acre, which, although not considered a good yield according to the La Laguna's standard, for the purpose of this demonstration was outstanding, the more so if we consider that, due to the early frost, many green cotton bolls which were already set but too young to open were lost, representing about 30 per cent of the crop, and also that no cotton was obtained from the untreated plot.

CONCLUSIONS.—The work reported in this paper and carried on as a demonstration of the effectiveness of new organic insecticides for the control of various cotton insect pests in late-planted cotton in the La Laguna District of Mexico, suggests the following points:

(a) Cotton insect pests can be effectively controlled by the proper use of adequate insecticides

(b) Where no cotton could formerly be picked due to insect damage, yields can be considerably improved through the use of insecticides.

(c) Frequent applications of insecticides at intervals of about 7 days are of the utmost importance.

(d) Benzene hexachloride, up to 6 per cent gamma isomer did not prevent a build up of pink bollworm infestation, for which DDT is necessary. A 2 per cent gamma isomer concentration of benzene hexachloride controlled the cotton aphid and will prevent the build up of a light boll weevil infestation if applied in time and at frequent intervals. For a heavy boll weevil infestation it might be necessary to apply benzene hexachloride with a higher gamma isomer content.

(e) It has been definitely demonstrated that the planting of cotton late in the season in the La Laguna District of Mexico is unprofitable for the farmer. Although insect pests can be controlled, the high populations at the time make it necessary to apply insecticides twice as many times as in a normally planted cotton field thus increasing the cost. Besides, early frosts will always constitute a menace to the late-planted cotton fields and might reduce the yields to such an extent that the final crop will not pay for the cost of insecticides nor even for the high costs of cotton cultivation in the La Laguna District.

INTERNATIONAL GREAT PLAINS CONFERENCE

The International Great Plains Entomological Conference will hold its 22nd Annual Meeting at the University of Wyoming Science Summer Camp, Centennial, Wyoming, on August 4, 5 and 6, 1949.

Chemical Control of the Alfalfa Caterpillar in California

RAY F. SMITH and WILLIAM W. ALLEN, *University of California, Berkeley*

Alfalfa is a very valuable crop because of its many cuttings and large acreage. But any particular cutting represents only a portion of the total yield from a field and the value per acre for each cutting is low. Thus, under ordinary conditions large sums of money cannot be spent for the control of insects attacking alfalfa hay. Furthermore, the insecticides which can be used against alfalfa insects are limited by the residue hazards to man, livestock, and beneficial insects. Because natural factors are so effective against the alfalfa caterpillar, *Colias philodice eurytheme* Boisduval, chemical control against this pest is only warranted on a small percentage of the total alfalfa acreage (Michelbacher & Smith, 1943; Wildermuth, 1914, 1920). In the San Joaquin Valley of California nearly all damage is restricted to a part of the third, fourth, and fifth crops. For example in 1947, of 50,141 acres in these cuttings in the Dos Palos area only 17,943 acres, or 35.8 per cent, were economically infested and of this, only 8,817 acres or 17.6 per cent required chemical treatment. In the remaining fields economic control was obtained by early cutting. Nevertheless, the lack of a satisfactory chemical control to supplement the natural controls of the alfalfa caterpillar has meant the loss of thousands of acres of alfalfa hay.

PREVIOUS USE OF INSECTICIDES.—Wildermuth (1911, 1914) working in southern California and in Arizona used "buhach" as a straight dust and as a 50 per cent dust at the rate of 3 pounds per acre with no positive results because, as so frequently happens, the very common polyhedrosis destroyed the population. In a later test straight pyrethrum flowers gave about 50 per cent control. Wildermuth, as have many other authors (Essig 1926; Cartwright *et al.* 1933; Dean & Smith 1936; Essig & Hoskins 1944), recommended cultural practices as the best available control. Others (Metcalf & Flint 1939; Shull & Fisher 1940) more recently have stated that spraying or dusting as recommended for the alfalfa weevil will give control. However, Smith & MacLeod (1943) in California, using a calcium arsenate-sulfur mixture at approximately twice the rate recommended for the alfalfa weevil obtained only a 37.9 per cent reduction as compared to an untreated check at seven days. Floyd (1940) reported copper arsenate and calcium arsenate to possess high toxicity to fifth instar larvae in laboratory tests although basic lead arsenate did not. Rotenone, even at rather high concentrations, is ineffective according to Floyd (1940) and Roark (1944, 1945).

Ordinary dusting sulfur at the rate of 50 to 75 pounds per acre has been more or less extensively used following the work of Smith and MacLeod (1943). Later Smith *et al.* (1945), pointed out some of the hazards involved in the use of sulfur for the control of the alfalfa caterpillar. Although sulfur under certain conditions gives satisfactory control, it has not been uniformly effective and much dissatisfaction has resulted. The difficulty lies in the fact that the conditions which are conducive to satisfactory control with sulfur are nor known, and if they were known, probably could not be forecast or controlled at time of treatment. Variations in the degree of control are probably related to temperature. In the Patterson area in 1947, where the July-August daily mean temperature averaged 71.4° F., only 74 per cent of the sulfur dusting gave satisfactory control, while in the Dos Palos area, where the July-August daily mean temperature averaged 75.8° F., 82 per cent of the dusting gave satisfactory control. In a portion of the acreage given here as having satisfactory control, the sulfur was slow in reducing the population. In addition to these erratic results, the use of sulfur has several other critical disadvantages. Since sulfur has a very low ignition point and is highly combustible when atomized with air, the fire hazard is very great when sulfur is applied as an insecticidal dust. This factor has been most important in militating against its use in southern California. Moreover, the residue of sulfur, even two weeks after treatment, may

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irritate the eyes of the balers at harvest time and in some cases where the hay is milled may provide a further fire hazard. Finally, the application of sulfur is also definitely harmful to the beneficial parasite, *Apanteles medicaginis* Muesebeck. These several factors have caused a decline in the use of sulfur for the control of the alfalfa caterpillar. In 1946 in the Westside Alfalfa Pest Control Association 95.9 per cent of the dusting for the control of the alfalfa caterpillar was with sulfur, in 1947 this dropped to 19.1 per cent, and in 1948 was only 1.3 per cent of the total acreage treated. Similarly, in the Patterson area where 92.4 per cent of the dusting was with sulfur dust in 1947, only 5.9 per cent was treated with sulfur in 1948.

THE USE OF DDT.—Another factor which has added to the decline in the use of sulfur is the advent of DDT. Michelbacher *et al.* (1945), mentioned that lepidopterous larvae were killed when an alfalfa seed field was treated with 3 per cent DDT dust at the rate of 28 pounds per acre. The Oklahoma Agricultural Experiment Station (1945) reported a 3 per cent DDT dust gave complete control of the alfalfa caterpillar in laboratory tests in 18 hours. The use of DDT in the Westside Alfalfa Pest Control Association is an example of the rise of this chemical for the control of the alfalfa caterpillar. In 1945 and 1946, in this district the applications of DDT were restricted to experimental studies and little more than 100 acres were treated. In other parts of California, a larger acreage was treated in 1946. In 1947, in the Westside Alfalfa Pest Control Association, 85.0 per cent (8,815 acres) of the chemically treated acreage, were treated with DDT and in 1948 this percentage rose to 98.7 per cent (3,863 acres). Accompanying this increased use of DDT the dosage of actual DDT per acre has decreased and the acreage treated by spraying has increased.

PROCEDURE.—Most of the materials discussed in this paper were applied by airplane dusters or sprayers. Since airplanes lack maneuverability, it was found convenient to use large test blocks of 4 to 20 acres.[1] The airplane sprayers were of the boom type and agitation in the tank was provided by a recirculation pump. This type of agitation was adequate where emulsions were used. As a result of the severe nature of alfalfa caterpillar damage it was not always possible to have untreated checks comparable to the treated blocks. The fields were selected for uniformity of stand and every effort was made to select those in which the parasite, *Apanteles medicaginis*, and the virus disease were at a low level. These biological checks have hampered past interpretations of the effectiveness of insecticides. The trends of the populations were followed by counts made as often as possible in each plot before and after treatment. The counts were made by the sweep method and in most instances the larvae were separated into size categories. Only the total larvae are reported in this paper. Ten to 30 stations were established in each plot and 1 to 5 sweeps made at each station. The tests were conducted in the San Joaquin Valley of California and included DDT, DDD, sulfur, dianisyl trichloroethane (methoxychlor), chlorinated camphene, chlordan, benzene hexachloride, parathion, tetraethyl pyrophosphate, rotenone, pyrethrum and piperonyl cyclonene.

RESULTS IN 1946.—In the summer of 1946 two preliminary experiments were conducted to test the efficiency of 0.5 per cent DDT, 3 and 5 per cent dianisyl trichloroethane, and straight dusting sulfur to control the alfalfa caterpillar. The rates of application and a summary of the results of these tests are presented in table 1. All three of these insecticides controlled the alfalfa caterpillar at the dosages used, and their use either increased the yield or quality of hay as compared to the untreated area. Although dianisyl trichloroethane and sulfur were used at much higher dosages than was the DDT, the control by DDT was much more rapid. Further investigations were indicated, since the number of adult *Apanteles* in the treated areas was reduced as compared to undusted areas. All of the dusts which contained sulfur reduced the number of *Apanteles* adults from 21 per 50 sweeps before treatment to 1.5 per 50 sweeps after treatment. The effect of the 0.5 per cent DDT was less severe. All populations of the parasite recovered and equalled those in the untreated area within 6 days. Although the yields of alfalfa from the plots treated with DDT and dianisyl trichloroethane were not

[1] Both the dusters and sprayers were converted N2S (Stearman) biplanes.

Table 1.—Control of the alfalfa caterpillar obtained with airplane applications of dusts in the San Joaquin Valley, 1946.

Treatment and Date Applied	Pounds per Acre	Total *Colias* Larvae per 20 Sweeps				
		Pre-treatment Counts		Post-treatment Counts		
		Date	Count	Date	Count	Percentage Reduction[1]
August 8:						
Dianisyl trichloroethane, 3.0%; inert, 97.0%	25.5	8/ 7	429	8/ 8	511	—
				8/ 9	298	30.5
				8/12	36	91.6
				8/16	0.7	99.8
Dianisyl trichloroethane, 5.0%; inert, 95.0%	26.4	8/ 7	429	8/ 9	178	58.5
				8/12	56	87.0
				8/16	7	98.4
DDT, 0.5%; sulfur, 95.0%; inert, 4.5%	41.0	8/ 7	429	8/ 8	23	94.6
				8/ 9	11	97.4
				8/12	0	100.0
				8/16	4	99.1
August 22:						
DDT, 0.5%; inert, 99.5%	33.2	8/22	29.9	8/23	23.5	21.4
				8/25	3.6	88.0
				8/29	0.2	99.3
DDT, 0.5%; sulfur, 95.0%; inert, 4.5%	44.2	8/22	19.9	8/23	11.2	43.7
				8/25	0.4	98.0
				8/29	0.1	99.5
Straight dusting sulfur	81.7	8/22	17.1	8/23	11.6	32.2
				8/25	1.6	90.6
				8.29	0.7	95.9

[1] Percentage reduction under pretreatment count.

significantly different in quantity, there was a very evident difference in the quality of the hay. Apparently the caterpillars in the slower-acting dianisyl trichloroethane plot consumed more leaves and thus lowered the quality of the hay before they died.

RESULTS IN 1947.—An attempt was made in 1947 to determine the minimum dosage of DDT which would give effective control. Two tests were made in which DDT was applied as a water-emulsion spray by airplane at the rate of 5 gallons of spray per acre. The pounds of actual DDT applied per acre and a summary of the results of these tests are given in table 2. The first experiment, in which DDT was applied at the dosages of 0.26, 0.53 and 0.78 pounds of actual DDT per acre, showed minor differences between treatments, but all three gave practically complete control in 48 hours. In a second experiment, where the pretreatment population was extremely large, DDT was compared at dosages of 0.10, 0.15, 0.21, and 0.26 pounds per acre. Marked reduction was evident four hours after treatment even in the plot treated with 0.10 pound of DDT per acre. However, at 24 hours after treatment, economic control had been obtained only in the plot treated with 0.25 pound of DDT per acre. Control of first, second, and third instar larvae was nearly complete in all plots and the reduction of the number of these smaller larvae under the pretreatment level ranged from 93.3 to 97.9 per cent. The larger larvae, however, were not so easily killed at these dosages. The control of fourth and fifth instar larvae at 4 hours ranged from 45.7 per cent reduction as compared to the pretreatment counts in the 0.10 pound per acre plot to 78.3 per cent in the 0.26 pound treatment. At 48 hours control was nearly complete in all plots ranging from 98.9 per cent at the lowest dosage to 100.0 per cent at the highest dosage.

In additional experiments, DDT dusts at concentrations ranging from 0.5 to 3 per cent were also tested. These dusts were applied by airplane at the rate of

approximately 30 pounds per acre (Table 3). The 3-per cent dust was tested once and gave over 99 per cent control (reduction as compared to the pretreatment count) in 24 hours. The 1-per cent dust was used in all 3 experiments and gave 68 per cent reduction at 10 hours, and 97.3 to 98.9 per cent at 24 hours. The 0.5 per cent dust was used in two tests in various mixtures and gave poor control at 10 hours, but by 48 hours was nearly as effective as the 1 per cent dust at 24 hours. The control with the 0.5 per cent dusts at 48 hours ranged from 92.4 to 99.9 per cent reduction as compared to the pretreatment counts. Different types of dust mixtures at the 0.5 per cent level did not seem to have much effect on control as based on total larvae killed. However, at 10 hours the mixture with 50 per cent sulfur gave a significantly greater reduction of fourth and fifth instar larvae than did the other mixtures.

Preliminary results were also obtained in the 1947 season on the effectiveness of materials other than DDT. One quart of 50 per cent hexaethyl tetraphosphate per acre in oil was tested and found to be inferior to both wettable DDT at 0.21 pound per acre and DDT in oil at 0.15 pound per acre as has been reported previously (Smith & Allen 1948). The hexaethyl tetraphosphate in oil also caused minor injury to the leaves. On the other hand, DDT has not caused any noticeable injury to alfalfa in any of our tests. At high dosages, *i.e.*, over 50 pounds per acre, 1 per cent gamma isomer of benzene hexachloride, 0.5 per cent gamma isomer of benzene hexachloride, 10 per cent toxaphene, and 5 per cent chlordan all gave over 95 per cent reduction at 48 hours.

Table 2.—Control of the alfalfa caterpillar obtained with airplane applications of DDT water-emulsions in the San Joaquin Valley, California, 1947.

Date Applied and Pounds of Actual DDT per Acre	Total *Colias* Larvae per Sweep				
	Pre-treatment Counts		Post-treatment Counts		
	Date	Count	Date	Count	Percentage Reduction[1]
July 19:					
0.78	7/18	25.2	7/21	0.0	100.0
			7/23	0.0	100.0
			7/28	0.0	100.0
0.53	7/18	20.2	7/21	0.01	99.9
			7/23	0.0	100.0
			7/28	0.0	100.0
0.26	7/18	22.8	7/21	0.09	99.6
			7/23	0.0	100.0
			7/28	0.0	100.0
August 13:					
0.26	8/11	141.8	8/13	40.6	71.4
			8/14	11.7	91.7
			8/15	0.2	99.9
			8/20	0.0	100.0
0.21	8/11	185.8	8/13	69.0	62.9
			8/14	27.0	85.5
			8/15	1.7	99.1
			8/20	0.0	100.0
0.15	8/11	182.4	8/13	70.8	61.2
			8/14	28.7	84.3
			8/15	1.7	99.1
			8/20	0.0	100.0
0.10	8/11	141.3	8/13	66.3	53.1
			8/14	28.7	79.7
			8/15	1.6	98.9
			8/20	0.5	99.6

[1] Percentage reduction under the pre-treatment count.

One of the greatest problems in the use of the organic hydrochlorides for the control of insect pests of forage crops is the residue hazard. All of the materials discussed here are more or less handicapped by the residues which they leave. Extensive DDT analyses were made in connection with the tests in 1947 and have been reported previously (Smith, Fullmer, and Messenger 1948; Smith, Hoskins, and Fullmer 1948). Even at the lower dosages (30 pounds of 0.5 per cent dust per acre) appreciable DDT was found on the alfalfa hay. When hay with a residue which averaged between 7 and 8 ppm was fed to dairy cows as their sole diet, they secreted 2.5 to 3.0 ppm DDT in the milk. Hay which was treated in 1947 with 0.25 pound of DDT per acre and stored in the bale for over a year, still contained roughly the same amount of DDT as when baled.

RESULTS IN 1948.—Since the residue studies conducted late in the 1947 season indicated that dairy cows are able to concentrate DDT in their milk even though fed alfalfa hay containing low amounts of DDT, the 1948 studies were designed to lower the dosage for the control of the alfalfa caterpillar to a point where no residue would remain on the hay. In addition further studies were undertaken to find other more suitable insecticides. Preliminary laboratory tests were conducted in the spring to compare DDT with parathion, dianisyl trichloroethane, cryolite, and dichlorodiphenyl dichloroethane. These tests indicated that at least under laboratory conditions DDT and parathion were definitely superior to the other materials. Dichlorodiphenyl dichloroethane was equal to DDT at the

Table 3.—Comparative effectiveness of various DDT dusts and sulfur applied by airplane for the control of the alfalfa caterpillar, San Joaquin Valley, 1947.

Treatments	Pounds per Acre	Date Applied	Total *Colias* Larvae per Sweep				
			Pre-treatment Counts		Post-treatment Counts		
			Date	Count	Date	Count	Percentage Reduction[1]
DDT, 3%	26.0	7/17	7/14	33.2	7/18	0.2	99.6
			7/16	52.5	7/21	0.0	100.0
					7/23	0.0	100.0
DDT, 1%	24.8	7/17	7/14	40.9	7/18	2.0	97.3
			7/16	72.5	7/21	0.3	99.7
					7/23	0.01	99.9
Sulfur	58.1	7/17	7/14	35.4	7/18	30.8	57.6
			7/16	72.6	7/21	2.1	97.1
					7/23	0.8	99.0
DDT, 1%	30.0	7/22	7/21	206.4	7/23	2.2	98.9
					7/25	0.0	100.0
					7/28	0.0	100.0
					8/1	0.02	99.9
					8/6	0.02	99.9
DDT, 1%[2]	30.0	7/22	7/21	145.8	7/23	2.9	98.0
					7.25	0.12	99.9
					7.28	0.07	99.9
					8/1	0.00	100.0
					8/6	0.00	100.0
DDT, 0.5%[3]	30.0	7/22	7/21	122.5	7/23	5.2	95.8
					7/25	2.8	97.7
					7/28	0.84	99.3
					8/1	0.1	99.9
					8/6	0.02	99.9
DDT, 0.5%[4]	30.0	7/22	7/21	116.9	7/23	18.4	84.3
					7/25	3.1	97.4
					7/28	1.4	98.8
					8/1	0.7	99.9
					8/6	0.1	99.9
DDT, 1%[2]	28.8	8/18	8/15	44.0	8/18	16.3	68.0
			8/17	51.0	8/20	1.1	97.9
					8/22	0.1	99.8
DDT, 0.5%[3]	29.9	8/18	8/15	41.8	8/18	28.9	51.3
			8/17	59.3	8/20	3.0	95.0
					8/22	0.6	99.0
DDT, 0.5%[4]	31.6	8/18	8/15	27.7	8/18	15.9	52.9
			8/17	33.7	8/20	1.6	95.4
					8/22	0.6	98.3
DDT, 0.5%	29.9	8/18	8/15	39.5	8/18	26.8	50.6
			8/17	54.3	8/20	0.1	99.9
					8/22	0.0	100.0
DDT, 0.5%; sulfur, 50%	28.9	8/18	8/15	43.0	8/18	37.5	54.6
			8/17	82.5	8/20	0.5	99.5
					8/22	0.02	99.9
DDT, 0.5%; oil, 2.0%	28.8	8/18	8/15	62.0	8/18	61.2	27.6
			8/17	84.5	8/20	6.4	92.4
					8/22	0.3	99.6

[1] Percentage reduction under last pre-treatment count.
[2] Ten per cent double strength dry multicide.
[3] Five per cent double strength dry multicide.
[4] Ten per cent dry multicide.

Table 4.—Comparison of one per cent DDT, dichlorodiphenyl dichloroethane, and parathion for the control of fourth and fifth instar alfalfa caterpillar larvae, Dos Palos, 1948.

		DDT		Dichlorodiphenyl Dichloroethane		Parathion		Untreated Check
Date	Time After Treatment	Count per 24 Sweeps	Percentage Reduction Under Check	Count per 24 Sweeps	Percentage Reduction Under Check	Count per 24 Sweeps	Percentage Reduction Under Check	Count per 24 Sweeps
7/27	Prior to treatment	210	—	243	—	196	—	224
7/29	12 hrs.	118	46.6	126	43.0	138	37.6	221
7/29	24 hrs.	95	44.8	130	24.4	119	30.8	172
7/30	36 hrs.	20	89.4	40	78.7	84	55.3	188

3 per cent level but definitely inferior at the 1 and 0.5 per cent levels. Cryolite and dianisyl trichloroethane were inferior to DDT even when applied at much higher concentrations. A small field test (Table 4) was conducted in the Dos Palos area to follow up these laboratory studies. DDT, dichlorodiphenyl dichloroethane, and parathion at the one per cent level were compared to an untreated check in a 4 by 4 latin square. Each replicate was 0.08 acre and the applications were made with hand dusters at the rate of about 22 pounds per acre. Under these field conditions and at this dosage DDT was superior to dichlorodiphenyl dichloroethane and parathion. The excellent results obtained with parathion in the laboratory may have been due to a fumigation effect in the confined conditions under which the larvae were held.

DDT and dichlorodiphenyl dichloroethane were further tested in water-emulsion sprays applied by airplane (Table 5). At a dosage of approximately 0.15 pound per acre, both materials gave a reduction of over 85 per cent in 24 hours. At 48 hours, this dosage of DDT gave 98.5 to 99.7 per cent reduction under the pretreatment count, while dichlorodiphenyl dichloroethane gave 96.7 per cent reduction. A reduction in the gallonage per acre from about 6.0 to 3.3 gallons did not seriously affect control. In one test 0.08 pound of DDT per acre gave satisfactory control although the rate of kill was slower than that of the 0.14 to 0.17 dosages.

Several other materials were tested in dusts against the alfalfa caterpillar in 1948. The composition of the dusts, the rates of application, and a summary of the results obtained with these materials are summarized in table 6. Chlorinated camphene gave satisfactory control at a rather high dosage compared to that required by DDT and dichlorodiphenyl dichloroethane. Benzene hexachloride gave excellent control at high rates of application (0.35 and 0.54 pounds of gamma isomer per acre) but was only fair at the low rate of 0.07 pound of gamma isomer per acre. At this dosage in this test it was approximately comparable to DDT both in comparison to the pretreatment counts and counts in untreated areas. Tetraethyl pyrophosphate (0.66 per cent) gave excellent control in one case at a rate of 23.5 pounds per acre but was not satisfactory in another in which the application was poor. Slight injury from tetraethyl pyrophosphate was noted in both tests wherever the dust was streaked. Pyrethrins (0.05 per cent) with 0.5 per cent piperonyl cyclonene were fairly effective although inferior to DDT and tetraethyl pyrophosphate. The addition of sulfur may make this combination an effective dust. Rotenone with piperonyl cyclonene was not satisfactory. Chlordan at the comparatively high rate of 1.25 pounds of actual material per acre and dianisyl trichloroethane at 0.34 pound per acre gave poor control. Julius Hyman "118" was applied as an emulsion at three rates with a knapsack sprayer. At 1 pound per acre an 86.1 per cent reduction as compared to the untreated check was obtained in 48 hours, with 0.50 pound per acre 74.5 per cent reduction was obtained in 48 hours, and with 0.25 pound, only 15.3 per cent control was obtained.

Discussion.—DDT provides a very effective control for the alfalfa caterpillar and gives satisfactory results even at re-

Table 5.—Comparison of DDT and dichlorodiphenyl dichloroethane applied by airplane as water emulsion sprays for the control of the alfalfa caterpillar, 1948.

Materials	Active Ingredient per Acre (Pounds)	Gallons of Spray per Acre	Pre-treatment Counts		Post-treatment Counts		
			Date	Count per Sweep	Hours After Treatment	Count per Sweep	Percentage Reduction[1]
DDT	0.34	6.5	8/18	9.9	19	0.89	91.0
					24	0.60	94.0
					44	0.03	99.7
					82	0.00	100.0
	0.15	—	8/18	12.0	19	0.50	95.8
					24	0.92	92.3
					44	0.06	99.5
					82	0.02	99.8
	0.16	6.0	8/18	10.6	19	1.38	86.9
					24	1.55	85.3
					44	0.03	99.7
					82	0.02	99.8
	0.14	5.5	8/19	15.5	19	2.92	81.2
					24	2.48	84.0
					44	0.17	98.9
					82	0.00	100.0
	0.14	3.3	8/19	13.5	19	3.41	74.8
					24	2.31	82.9
					44	0.20	98.5
					82	0.00	100.0
Dichlorodiphenyl dichloroethane	0.32	6.5	8/18	13.9	19	0.92	93.4
					24	1.23	91.2
					44	0.20	98.6
					82	0.04	99.7
	0.15	5.7	8.18	15.9	19	1.38	91.3
					24	1.95	87.7
					44	0.53	96.7
					82	0.08	99.5
DDT	0.17	6.9	9/7	32.1	19	2.13	93.4
					26	3.31	89.7
					48	0.28	99.1
					72	0.06	99.8
	0.08	6.5	9/7	49.5	19	7.13	85.6
					26	9.87	80.1
					48	2.33	95.3
					72	0.93	98.1
Untreated	—	—	9/7	27.2	19	23.10	15.0
					26	17.68	35.0
					48	18.30	32.7
					72	19.60	27.9

[1] Percentage reduction under the pre-treatment count.

markably low dosages. With the most severe infestations over 95 per cent control has to be obtained within 24 hours. It appears from the results given here that 25 pounds of 1 per cent dust or 0.13 pound of DDT applied as a spray will give satisfactory control of even the most severe infestations. With lighter infestations or where the outbreak can be forecast early enough, smaller dosages may be satisfactory. With these lighter infestations, 0.5 per cent DDT dust or 0.10 pound DDT per acre as a spray would appear to be adequate. These smaller dosages do not kill the fourth and fifth instar larvae as rapidly as the higher

Table 6.—Comparison of insecticides applied as dusts for the control of the alfalfa caterpillar, 1948.

Materials	Rate per Acre (Pounds)	Active Ingredient per Acre	Percentage Reduction Under Pre-treatment Counts		
			24 Hrs.	48 Hrs.	96 Hrs.
Chlorinated camphene, technical, 10%; inert, 90%	22.0	2.2	83.9	94.8	97.8
	89.0	8.9	—	99.7	—
Chlordan, technical, 5%; inert, 95%	25.0	1.25	23.0	52.8	65.3
	95.0	4.7	—	96.0	—
Benzene hexachloride, gamma isomer, 0.5%, other isomers, 3.5%; inert, 96.0%	13.8	0.07	69.8	70.1	94.4
	70.0	0.35	—	99.9	—
Benzene hexachloride, gamma isomer, 1.0%, other isomers, 7.0%; inert, 92.0%	54.0	0.54	—	100.0	—
Dianisyl trichloroethane, 3.0%; inert, 97%	11.5	0.34	73.0	77.8	84.2
Tetraethyl pyrophosphate, 0.66%; other related organic phosphates, 1.0%; inert, 98.34%	23.5	0.16	97.2	98.9	—
	22.7	0.15	51.1	—	—
Tetraethyl pyrophosphate, 0.50%; other related organic phosphates, 1.0%; inert, 98.5%	20.8	0.10	50.0	—	—
Pyrethrins, 0.05%; piperonyl cyclonene, 0.50%; inert, 99.45%	27.9	0.15	78.9	89.5	—
Rotenone, 0.25%; piperonyl cyclonene, 0.50%; inert, 99.25%	26.7	0.20	34.3	54.9	—
DDT, 0.5%; inert, 99.5%	16.6	0.08	68.1	67.4	85.9
DDT, 1.0%; inert, 99.0%	26.0	0.26	98.4	99.5	—

ones, but the mortality of smaller larvae and the total mortality at 48 hours is satisfactory except under the most severe conditions. Timing is particularly important with these smaller dosages, as it is best to treat before a majority of the larvae have reached the fifth instar.

Under some conditions the pupation of large numbers of larvae may give the false impression of reduction due to chemical control. It may be more economical in certain cases to use more concentrated dusts at a lower poundage per acre. However, when the poundage is decreased with the increase in concentration of the dust, the pounds of DDT per acre must be increased to compensate for the poorer application which nearly always results (Table 7). Growers have used 10 pounds of 4 per cent dust successfully, but over 3 times as much actual DDT is applied per acre as with the 0.50 per cent dust. Dusts leave less residue than the sprays but require more DDT per acre to control. Even at the lowest dosages of both sprays and dusts, appreciable DDT can be found on the hay (Smith, Fullmer, and Messenger 1948). Until the hazard of these low residues is fully determined it would seem wise to keep the application of DDT to the lowest amount per acre possible. At the present time the only material which might be substituted for DDT is dichlorodiphenyl dichloroethane.

Table 7.—Analysis of the cost to obtain satisfactory control of the alfalfa caterpillar with various concentrations of DDT dust.

Concentration of Dust (Percentage)	Pounds Dust[1]	Actual DDT per Acre (Pounds)	Cost of Application per Acre (Dollars)	Cost of Dust per Acre (Dollars)	Total Cost per Acre (Dollars)
0.5	25	0.125	1.25	0.95	2.20
1.0	20	0.200	1.00	0.89	1.89
2.0	15	0.300	0.75	0.87	1.62
3.0	12	0.360	0.60	0.85	1.45
4.0	10	0.400	0.50	0.83	1.33
5.0	9	0.450	0.50	0.85	1.35

[1] Approximate dosage per acre required to obtain satisfactory control with airplane application.

The other tested compounds are either far too hazardous or are inadequate at dosages which are at all economically feasible. Dichlorodiphenyl dichloroethane is not quite as effective as is DDT, but dosages as low as 25 pounds of a 1 per cent dust and 0.13 pound in a spray have been effective. The residue hazard is less than that of DDT.

Infestations of the alfalfa caterpillar vary markedly from field to field due to the habits of the pest and its parasite, *Apanteles medicaginis* Muesebeck. Because of these uneven infestations and since the parasite may be seriously harmed by chemicals, control of the pest should be applied only on the basis of careful and adequate caterpillar population counts.

SUMMARY.—The history of chemical control of the alfalfa caterpillar, *Colias philodice eurytheme* Boisduval, is reviewed with particular emphasis on the use of new organic materials. The materials which show the most promise for the control of the alfalfa caterpillar are DDT and DDD. Chlordane, benzene hexachloride, chlorinated camphene, dianisyl trichloroethane, tetraethyl pyrophosphate, piperonyl cyclonene with rotenone and pyrethrins, and parathion were tested in a preliminary way. They either gave inferior control as compared to DDT or presented a more hazardous residue problem. DDT is effective at dosages as low as 25 pounds of 0.50 per cent dust per acre or 0.15 pound of DDT per acre applied as a spray-emulsion. DDD must be used at slightly higher dosages than DDT to obtain comparable control, but it has a lower residue hazard. Until more information is available on the danger of low residues, DDT cannot be recommended for use on alfalfa hay.

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Organic Insecticides to Control Alfalfa Insects[1]

M. Curtis Wilson, *Purdue University Agricultural Experiment Station, Lafayette, Indiana*

Preliminary studies were initiated during the summer of 1948 to determine the effect of insect control on alfalfa seed production. An alfalfa field in Tippecanoe County, located on an upland terrace soil with a substratum of calcareous shale, was used. The field was ideal for alfalfa seed production as it had good drainage and was located next to a heavily wooded area. This wooded area and the fence rows surrounding the field afforded ample shelter for pollinators.

Methods.—A replicated plot experiment was laid out in the center of the field, using an area of 420×336 feet. Each plot measured 200 feet by 28 feet. A road, 20 feet wide for turning, was placed between the first two replicates and the latter two replicates. All alfalfa surrounding the experimental area was cut for hay. The first hay crop was taken from the field in June and this experiment was conducted on the second crop. Insecticidal spray treatments were applied on July 12, in the pre-bloom state, care being taken to apply the materials when the plants were fully budded just prior to breaking into bloom. Wettable powders were used made up into 50 gallons of spray. The materials were applied with a 50-gallon estate sprayer with a delivery rate of 4 gallons per minute. Accurate control was maintained so that the following materials were applied at the following dosages: DDT, 2 pounds per acre; a combination of 1 pound of DDT and 0.5 pound of chlordan per acre; chlordan, 1 pound per acre; methoxychlor, 1 pound per acre; and parathion, 0.5 pound per acre. Only one application was made. Insect population data were taken 1 week and 4 weeks after treatment with an insect sweep net, 20 sweeps being made in each plot. At the time of harvest, 30 stems were selected at random from each plot and from these, plant bug injury, the amount of pollination and the yield were determined. Eighteen separate random square-foot samples making 2 square yards were also harvested for seed yields. From these data, the yield per acre was determined. Combine samples were not considered accurate due to the loss of seed in the process, and were not taken.

Pollinators.—The honeybee, a poor tripper of alfalfa flowers, is not considered to effect enough pollination to produce an ample seed crop. It is believed to succeed in tripping the flowers on only one raceme out of every seven or eight visited. However, the large populations of honeybees frequently found working in alfalfa fields continuously during the blooming period help to compensate to some extent for its poor and unreliable tripping ability. It must not be overlooked that the honeybee often cross pollinates open-tripped flowers that have been tripped by various other causes. To aid the natural pollinators in the field, two hives of bees were placed close to the experimental plots. As the alfalfa was practically the only plant in bloom at that time in the vicinity, the bees were forced to work it.

Solitary bees are the most valuable pollinators and an abundant population of andrenids was present in the field. Sweat bees usually trip several alfalfa blossoms on a raceme before shifting to another plant. Even though two hives of honeybees were placed near the field, there were as many andrenids as honeybees in the plots 1 week after treatment. Four weeks after treatment the andrenid population exceeded the honeybee population 1.68 times. No mortality of bees was noted as a result of insecticidal action. One week after treatment, the increased bloom on treated plots attracted many more bees than the untreated plots. The bee population continued high on these treated plots over a period of 4 weeks.

Injurious Insects.—The most important economic species in the field were the potato leafhopper, *Empoasca fabae* Harris, clover leafhoppers (*Agallia* sp.), spittle bugs (Cercopidae), and the plant bugs *Lygus pratensis oblineatus* Say, *Adelphocoris lineolatus* (Goeze) and *A. rapidus* (Say). Data collected 1 week and 4 weeks after treatment are summarized in table 1. These data were analyzed statistically and the least required difference for both significance and high significance is listed for each insect.

[1] The author is indebted to Ralph Davis of the Agronomy Department for his cooperation in obtaining seed yields.

Potato Leafhoppers.—When applied at the following per acre rate, there was no significant difference between treatments of two pounds of DDT, one pound of DDT combined with one half pound of chlordan, one pound of methoxychlor and one half pound of parathion. All of these treatments gave very high control with long residual effect. However, chlordan, when applied alone, seemed to have an attracting effect on the leafhoppers. One week after treatment, the potato leafhopper population increased on chlordan treated plots 140 per cent or 2.4 times the untreated and by the end of 4 weeks, increased 213 per cent or 3.1 times. The plants in the chlordan plots yellowed and were stunted in sharp contrast to the untreated plots which were also seriously injured by the leafhoppers but didn't sustain such high numbers.

Clover Leafhoppers.—No clover leafhoppers were found the first week after treatment, but they were collected 4 weeks after treatment. Their small numbers are probably due to the small amount of clover present in the field. The residual effect of DDT, methoxychlor and parathion was evident 4 weeks after treatment, these materials showing high significance over the control. As with the potato leafhopper, clover leafhopper populations also increased on plots treated with 1 pound of chlordan per acre.

Spittle Bugs.—All materials gave highly significant control of adult spittle bugs the first week after treatment, and the data indicates that methoxychlor gave significantly greater control than parathion. Although not significant, slightly higher control was obtained with methoxychlor than with DDT and chlordan. Four weeks after treatment there was no significant difference between treated and untreated plots, indicating that there was little residual effect.

Plant Bugs.—Although the tarnished plant bug was predominant in the field, two other species, the alfalfa and rapid plant bugs were also present. Significant control was obtained with chlordan and DDT the first week and highly significant control was obtained with parathion. Methoxychlor was completely ineffective against plant bugs. Four weeks after treatment the residual effect of DDT, chlordan and parathion was very highly significant.

ALFALFA SEED YIELD DATA.—Thirty stems from each plot were selected at random and from the average number of developed and undeveloped rachides, the number of rachides bearing pods, and the number of pods produced were counted. The pods were dried and the seed hulled and cleaned. This seed was weighed and the total seed yield in grams per stem and the number of seed per gram per treatment were determined.

Analysis showed that there was no significant difference between treatments in the total number of rachides produced. A large number of undeveloped rachides were found on untreated plots and treatments where plant bugs were not controlled, and a highly significant error correlation of .81 between the number of plant bugs and aborted rachides was obtained. There was no correlation between aborted rachides and potato leafhoppers.

Table 1.—Average populations of injurious insects per 20 sweeps per plot 1 week and 4 weeks after treatment.

Treatment	Potato[1] Leafhopper		Clover Leafhopper		Spittle Bug		Tarnished Plant Bug				Total[2] Plant Bugs All Stages	
							Nymphs		Adults			
	1 Wk.	4 Wks.	1 Wk.	4 Wks.	1 Wk.	4 Wks.	1 Wk.	4 Wks.	1 Wk.	4 Wks.	1 Wk.	4 Wks.
1. Untreated	38.8	112.8	0	4.0	21.8	13.0	7.25	9.75	10.75	15.25	25.5	26.25
2. DDT 2 lb. per acre	1.3	6.3	0	0.5	8.3	9.0	0.25	0	7.0	3.5	8.25	6.25
3. DDT 1 lb. Chlordan 0.5 lb. per acre	4.8	10.0	0	2.5	10.5	4.8	0	0	5.75	2.5	6.5	2.75
4. Chlordan 1 lb per acre	92.8	352.8	0	10.0	11.0	6.5	0	0.5	5.5	4.25	7.0	5.25
5. Methoxychlor 1 lb. per acre	1.8	14.3	0	0.5	6.0	7.3	3.75	10.5	14.0	9.75	27.25	24.25
6. Parathion 0.5 lb. per acre	4.0	12.5	0	0.25	12.0	6.5	0	1.75	3.0	3.75	3.5	6.25
Least req. sig. dif. (19:1)	38.1	122.5		4.4	5.9	insig.	3.8	3.6	4.4	7.9	15.5	13.7
Least req. sig. dif. (99:1)	51.6			6.1	8.0	insig.	5.3	5.0	6.0	10.9	21.5	19.0

[1] Analysis of potato leaf hoppers—chlordan excluded.

Least req. sig. dif. (19:1)	22.1	52.2
Least req. sig. dif. (99:1)	30.9	72.8

[1] The potato leafhopper population on chlordan treated plots was so much higher than on untreated plots that the calculated least required differences were too high to show the obviously high significant differences between the other materials and the control. Therefore, an analysis exclusive of chlordan is included.

[2] Alfalfa plant bug, rapid plant bug, and tarnished plant bug.

Table 2 lists the average total number of seed pods obtained per stem and shows that the treatments effecting highest insect control also produced the largest number of pods. The differences between the three best treatments: DDT in combination with chlordan, DDT alone, and parathion, and the untreated plots is significant with the combination of DDT and chlordan being near high significance. The difference between chlordan plots and the three above mentioned treatments is highly significant. These data show that these treatments greatly reduced the population of injurious insects, and consequently, increased the bloom of the alfalfa. Therefore, many more pollinators were attracted to these treated plots with a resultant increase in pod production by the plants. This corroborates the fact that even though these insecticidal materials are highly toxic to bees, proper timing of application when the bees are not present in the field appears to eliminate the hazard of killing these pollinators.

Table 2.—Increase in seed pods produced on treatments effecting high insect control.

Treatment	Seed Pods per Stem
No treatment	42.73
DDT: 2 lb. per acre	65.10
DDT: 1 lb., chlordan 0.5 lb. per acre	75.63
Chlordan: 1 lb. per acre	33.79
Methoxychlor: 1 lb. per acre	54.51
Parathion: 0.5 lb. per acre	69.27
Least req. sig. dif. (19:1)	24.59

The seed yields calculated from 30 stems per plot are tabulated in table 3. The number of seed in a gram for each treatment was determined. The large number of seed in a gram from the chlordan treatment was highly significant and indicates that this treatment which harbored so many leafhoppers produced inferior seed. A gram sample from the parathion treatments contained fewer seed very closely approaching significance. This is indicative that parathion treatments may improve the seed quality.

It may be noted that the actual yields do not all show significant differences from the checks, but are very close to significance. The combination of DDT with chlordan shows a significant increase in seed yield and was the best treatment. Calculated yield increases and decreases are listed in the last column of table 3.

Table 3.—Average alfalfa seed yields calculated from 30 stems per plot.

Treatment	Seed Yield in Grams per 30 Stems	Number of Seed per Gram	Number of Seed per Stem	Yield Increase or Decrease
Untreated	5.18	668.5	114.98	0
DDT: 2 lb. per acre	9.78	653.0	212.87	85%
DDT: 1 lb., chlordan: 8 oz. per acre	10.62	657.0	232.57	102%
Chlordan: 1 lb. per acre	3.41	755.0	86.07	−25%
Methoxychlor: 1 lb. per acre	5.57	686.5	126.90	10%
Parathion: 8 oz. per acre	9.96	622.0	206.50	79%
Least req. sig. dif. (19:1)	5.5	51.7	118.01	

Quadrat samples harvested in the field indicate a high yield increase on plots treated with DDT, DDT in combination with chlordan, and parathion. The tabulation of these data await the completion of a small threshing machine for this work.

Although these data show highly signficant results no recommendations are being made as this is a preliminary report of results of work of the first season on a project begun at Purdue.

A New Chlorinated Insecticide for Control of Turf-Inhabiting Insects

JOHN C. SCHREAD, *Connecticut Agricultural Experiment Station, New Haven*

A newly developed chlorinated hydrocarbon insecticide having the empirical formula $C_{12}H_8Cl_6$, (1,2,3,4,10,10-hexachloro-1:4, 5:8-diendo-methano-1,4,4a,5,-8,8a-hexahydronaphthalene) and known by the manufacturer's code number as "Compound 118," was used experimentally for the first time in 1948 for the control of turf-inhabiting insects. Nothing was known prior to these experiments about the effect of the toxicant on injurious soil insects, lawn grasses and weeds. Furthermore no information was available on the residual properties of the insecticide when applied to noxious insects in turf.

JAPANESE BEETLE.—Experiments in the control of Japanese beetle grubs were started in midsummer, 1948, using three dosages of "Compound 118" at 1, 3 and 6 pounds of actual toxicant per acre. Three plots of 0.0625 acre each were treated with 2.5, 7.5 and 15.0 pounds of 2.5 per cent dust. To facilitate distribution, especially at the two lowest levels, fertilizer[1] was mixed with the dust at the rate of 50 pounds per plot, and the mixture was applied on August 11. A total of 2.55 inches of rain fell during the first 24 hours after treatment. Table 1 gives the results of the treatments.

At all dosage levels the compound caused a high mortality of the grub populations within ten days and prevented turf injury in the areas treated. By September 22 no grubs were found in the treated plots. Concurrently, however, there was an average of 25 grubs per square foot in the untreated plots, resulting in serious injury to the turf. The data on oviposition indicate that eggs are normally laid in treated sod.

On August 31 an acre of grub-infested turf was treated, using a 25 per cent wettable powder at the rate of 48 pounds to the acre mixed with 80 pounds of fertilizer. This experiment was designed to draw a comparison between the dust and wettable toxicants. The grub population before treatment was made averaged 38 per square foot with a high of 60 and a low of 22. Table 2(1), gives the results of the experiment.

Despite the fact that the insecticide remained on the surface of dry turf in direct sunlight for virtually 12 days before being wetted by rain and for the remainder of the initial trial period of 4 weeks received only 0.42 inch of precipitation, all the grubs were killed in 28 days. The turf was not injured by the toxicant.

In order to determine rapidity of kill in early to mid-autumn, as the days grow shorter and the daily mean temperature lower, additional experiments were carried out. On September 23 a plot having an average of 75 grubs per square foot was treated with 2.5 per cent dust at the rate of 150 pounds to the acre. The dust was mixed with fertilizer. A total of 0.52 inch of rain fell between the time of treatment and October 7, when the plot was examined. Results are tabulated in table 2, (2). Plot examination at the end of 2 weeks indicated that the infestation had been reduced from 75 to 9.6 per square foot, a

Table 1.—Japanese beetle grub control.

Actual Toxicant per Acre	Grubs[1] per Sq. Ft. Before Treatment Aug. 11	Grubs[1] per Sq. Ft. After Treatment Aug. 21	Reduction Aug. 21	Grubs[1] per Sq. Ft. Sept. 22	Eggs[1] per Sq. Ft. Aug. 22	Eggs[1] per Sq. Ft. Sept. 22
1 lb.	22.3	4.6	82.7%	0.0	12.6	0.0
3 lbs.	23.3	2.3	90.9%	0.0	4.0	1.0
6 lbs.	22.3	0.3	98.5%	0.0	5.3	0.0
Untreated		33.0		25.0	4.5	0.0

[1] Data represents the average of 3 diggings per 0.0625 acre plot.

Table 2.—Japanese beetle grub mortality.

Expt. No.	Date Started	Actual Toxicant per Acre	Grubs[1] per Sq. Ft. Aug. 31	Grubs[1] per Sq. Ft. Sept. 28	Per Cent Reduction Sept. 28	Eggs[1] per Sq. Ft. Sept. 28
(1)	Aug. 31	12 lbs.	38	0.0	100	1.0
		untreated		27.5		0.0
			Sept. 23	Oct. 7		
(2)	Sept. 23	3.75 lbs.	75	9.6	87.2	
		untreated		69.0		
(3)	Sept. 23	5.0 lbs.	20.0[2]	1.0	95.2	
			33.3[3]	3.0	91.7	
		Untreated		23.0[2]		
				34.5[3]		

[1] Data represents the average of 48 diggings per acre plot.
[2] Japanese beetle grubs.
[3] Asiatic garden beetle grubs.

reduction of 87.2 per cent. Grub mortality in autumn when the soil temperature at the 3-inch level averaged 67° F. was not quite as rapid as in midsummer when the average soil temperature was 84.5° F (table 1). This in large measure was due not only to a much higher temperature at the time of and subsequent to the August 11 (Table 1) treatment but likewise to heavy rain which fell immediately following this later treatment.

On the same date a second experiment was started in turf having a mixed grub population comprising 20 Japanese beetle and 33.3 Asiatic garden beetle, *Autoserica castanea* Arrow, grubs per square foot. A 2.5 per cent dust was applied at the rate of 200 pounds to the acre. Results of the treatment appear in table 2(3). Due to the absence of precipitation until the seventh day following the treatment, a high degree of mortality for both grub species was not obtained until 14 days.

This insecticide was compared with chlordan and parathion at low dosage levels for control of Japanese beetle grubs in turf. The experiments were conducted under comparable conditions in August, 1947 and 1948.

At the 1 pound level of actual toxicants "Compound 118" gave better results in 1948 than parathion in 1947 in reducing Japanese beetle grub infestation in 10 days in August. At 3 and 6 pounds the toxicant was as good as parathion at 4 and 8 pounds and perhaps better. The differences may be questionably significant. At 1 pound of actual toxicant per acre "Compound 118" gave better results in reducing grub population in 10 days than chlordan at a comparable dosage level in 4 weeks. Furthermore, 3 pounds were measurably superior in destroying grubs in 10 days than 5 pounds of chlordan in four weeks. In 10 days 6 pounds per acre gave greater grub reduction than 10 pounds of technical chlordan in 2 weeks.

Chinch Bug.—During the summer and early fall of 1948 the chinch bug, *Blissus leucopterus* var. *hirtus* Bois., appeared to be more widespread and destructive to turf than for several years. In many localities there was extensive permanent injury to turf some of which was made up of pure

Table 3.—Comparison with chlordan and parathion.

"Compound 118" Aug. 11, 1948	Actual toxicant per acre	1 lb.	3 lbs.	6 lbs.
	Grub reduction in 10 days	82.7%	90.9%	98.5%
Parathion Aug. 22, 1947	Actual toxicant per acre	1 lb.	4 lbs.	8 lbs.
	Grub reduction in 2 weeks	69.7%	91.8%	95.2%
Chlordan Aug. 13, 1947	Actual toxicant per acre	1 lb.	5 lbs.	10 lbs.
	Grub reduction	75.0%[1]	85.7%[1]	93.2%[2]

[1] In 4 weeks.
[2] In 2 weeks.
Data represents forty diggings made per acre.

bent and the balance of bent, bluegrass and fescue.

Experiments comparing "Compound 118" with DDT, DDT plus Sabadilla, and chlordan were started on August 5 to determine their relative value for control of this insect. All four plots were 2500 square feet in area. The insecticide was used in plot 1 at the rate of 5 pounds of 2.5 per cent dust to 1000 square feet or 12.5 pounds to the plot. Chlordan was applied to plot 2 as a 5 per cent dust at the rate of 5 pounds to 1000 square feet or 12.5 pounds to the plot. Plot 3 was treated with 2.3 pounds of the DDT plus Sabadilla formulation per 1000 square feet, or 5.75 pounds per plot. DDT was also used alone in plot 4 at the rate of 6 pounds per 1000 square feet or 15 pounds per plot. To facilitate distribution, the insecticides were applied with fertilizer at the rate of 20 pounds to 1000 square feet or 50 pounds per plot. About one-half inch of rain fell immediately following the treatments but this did not appear to retard or impair the efficiency.

On August 11, 6 days after treatments the "Compound 118" and chlordan plots were still without chinch bug infestation. The areas of turf that had turned brown as a result of chinch bug feeding, prior to treatments, were obviously recovering and the brown cast was being replaced by a healthy, green color. In plots 3 and 4 there were quite a number of active adult chinch bugs, more in plot 3 than in 4. An occasional active nymph was also seen in plot 4. On August 15, 10 days after date of treatment, plots 1, 2 and 3 were free of chinch bugs. An occasional active adult was found in the DDT plot at this time, but by August 21 this plot was free of infestation.

The plots were examined at weekly intervals throughout the balance of August and through September. A few adult chinch bugs were found in the DDT and DDT-Sabadilla plots during the eighth week subsequent to treatment, but the other two plots remained uninfested. For the most part these results were further substantiated in a second series of experiments using all of the insecticides but the new compound. Untreated turf adjacent to the experiments remained infested by chinch bugs throughout August and September, but this did not constitute any serious threat to the treated plots.

ANTS.—On August 23, 1948, a 4500 square foot putting green, composed of colonial bent grass with an occasional small patch of velvet bent, infested with 6500 colonies of the cornfield ant, *Lasius niger* L. var. *americanus* Emery, was treated with "Compound 118." A 25-per cent wettable powder was applied at the rate of 4 ounces to 1000 square feet in 200 gallons of water, using a hydraulic spray machine with pump pressure maintained at 200 pounds. A garden hose with the nozzle open as wide as possible completed the equipment. Immediately following the treatment the turf was thoroughly watered for 30 minutes. Although the quantity of water used may seem excessive, it is necessary for best results. The day was hazy with a temperature of 90° F. prevailing during the hour of treatment. Humidity was high.

Twenty-four hours after the treatment was made an examination of the green showed that the infestation had been eliminated. There were no ant hills on the treated turf, whereas on an adjacent untreated green an excessive number persisted. On September 1 three ant hills appeared on the western edge of the treated green, but no more were seen for the remainder of the season.

A mound 5 feet in diameter constructed by the mound building ant, *Formica exsectoides*, was dusted with 1 ounce of 25 per cent wettable powder mixed with 1 pound of dry sifted sand to facilitate distribution. The surface of the mound was then scratched lightly to a depth of about an inch. Almost immediately the colony became extremely agitated and scores of workers hurried forth from all parts of the mound and its periphery. Many individuals made an effort to escape while others dug their way back into the mound. Twenty-four hours later thousands of dead and dying worker ants were found in entrance-ways to the mound on its perimeter as well as in depressions in the mound itself. On closer examination many pupae and larvae were seen intermingled with the workers that in all probability had vainly attempted to remove the immature stages to safety. By the second day all activity had ceased, no living ants were seen and none was unearthed when portions of the mound and subterranean galleries were excavated. The undisturbed portions of the colony were examined

periodically for the remainder of the season; however, no sign of living ants was seen at any time. By mid-fall grass had grown up to virtually obliterate the colony site.

INJURY TO TURF.—A 2.5 per cent dust, 25 per cent wettable powder and an emulsifiable concentrate were applied at dosage levels of from 1 to 12 pounds of actual toxicant per acre without injuring bent grasses, bluegrass or fescue. On one occasion, when the air temperature was 104° F., both the dust and wettable powder were applied to portions of a golf course green at ten pound levels of technical toxicant per acre. Both materials were applied dry, mixed with fertilizer to facilitate distribution. The turf was then watered thoroughly. During the succeeding three days the highest air temperature averaged 100° F., and no rain fell for 6 days. No injury to the turf was evident during the first few days following the treatments or subsequently.

SUMMARY.—"Compound 118" at effective dosage levels compares favorably in toxicity with chlordan and parathion for control of Japanese beetle grubs. At 1, 3 and 6 pounds of actual toxicant per acre it is as effective as 1, 4 and 8 pounds of parathion and 1, 5 and 10 pounds of chlordan. When applied to chinch bug infested turf at 5 pounds of actual toxicant per acre it was shown to be as effective as 10 pounds of chlordan and superior to 15 pounds of DDT plus Sabadilla or 26 pounds of DDT alone. A 25-per cent wettable powder applied at the rate of 4 ounces to 1000 square feet of turf infested with *Lasius niger* eliminated the infestation in 24 hours and prevented significant reinfestation for the balance of the season. One ounce of 25 per cent wettable compound effectively destroyed a 5-foot colony of the mound building ant *Formica exsectoides*. At dosage levels from 1 to 12 pounds of "Compound 118" per acre no injury to grass occurred.

Fall Armyworm Control on Forage and Truck Crops

RICHARD N. HOFMASTER and DOUGLAS E. GREENWOOD,
Virginia Truck Experiment Station, Norfolk

During the summer of 1948, extremely heavy outbreaks of the fall armyworm, *Laphygma frugiperda* (A. & S.), developed in Virginia. Although armyworm infestations are of regular occurrence in this area, extensive damage is usually limited to a comparatively short period in late summer. However, armyworms were present in such numbers by July 1, 1948, that entire fields of corn were completely destroyed. With such an early start, populations increased to almost unbelievable proportions by September 1.

Previous efforts at field control of the fall armyworm in this area have centered largely around the use of the conventional poison bran baits. Several objectionable features such as ineffectiveness under certain conditions, difficulty of application, and high cost have accentuated the need for more practicable control measures. Since direct application by means of dusts or sprays would afford a more convenient method of insecticidal control, tests along these lines were made with several of the newer materials. The present paper is primarily an evaluation of these insecticidal treatments for general armyworm control along with special consideration of some of the safer materials for use in pastures and hay fields.

CONTROL OF CORN AND SORGHUM.—Dust treatments were made July 8 on late field corn located near Norfolk, Virginia. At this time the corn was eight to ten inches high and had a very uniform infestation of approximately 1.5 armyworms per plant. Many of the armyworms had reached the fifth or sixth instar and, for the most part were feeding deep within the whorls. Application was made by hand equipment at the rate of approximately 35 lbs. of dust per acre. With the exception of parathion and bis (methyoxyphenyl) trichloroethane which were factory mixed, the dusts used in this and all other tests were prepared by adding the concentrate to a diluent, pyrophyllite, and mixing in a ribbon blade dust mixer for 20 minutes. All plats were 100 feet long by 4 rows wide and were replicated four times within randomized blocks. Records were taken by selecting 100 plants at random from each treatment and recording the number of live worms and uninfested plants. The materials

Table 1.—Results of dusting field corn for fall armyworm control July 8, 1948. Norfolk, Virginia.

Treatment	Live Worms Per 100 Plants and Per Cent Reduction Below Check After 24 Hours		Plants Uninfested Per 100 Plants and Per Cent Increase Above Check After Treatment			
			Number		Per Cent	
	Number	Per Cent	24 Hours	48 Hours	24 Hours	48 Hours
3% DDT—Regular	32	78	71	82	65	78
2.5% Methoxychlor—Impregnated	73	51	41	—	35	—
3% Chlordan	61	57	52	65	46	61
0.5% Parathion	30	79	74	79	68	75
1% Parathion	30	79	75	85	69	81
2% Parathion	4	97	96	97	90	93
5% "Toxaphene"	63	56	58	76	52	72
5% Ditolyl trichloroethane[1]	81	44	40	—	34	—
1% gamma isomer of benzene hexachloride	27	81	80	89	74	85
Untreated Check	145	—	6	4	—	—
Difference for significance (19 to 1 odds)	34		19			

[1] *Gytol.*

applied and results obtained are presented in table 1.

The above table indicates that, at the end of 24 hours, 2 per cent parathion dust was appreciably more effective than any other material. Other dusts showing promise were 1 per cent gamma isomer of benzene hexachloride, 1 per cent parathion, 0.5 per cent parathion and 3 per cent DDT. Forty-eight hour counts showed little change in relative effectiveness with the exception that 5 per cent chlorinated camphene had increased almost to a par with 3 per cent DDT. Brooks & Anderson (1947) also obtained promising results with DDT and benzene hexachloride dusts. These workers found 5 per cent chlordan dust slightly superior to 3 per cent DDT dust.

Of the materials tested in this experiment, DDT was eventually selected as having the best possibilities for general use in armyworm control at the present time. Performance, availability, cost and known toxicity to man and animals were the factors warranting primary consideration. Further experimentation (table 2) indicated that increased control could be obtained through modifying the DDT formulation employed. Preliminary tests with three DDT dusts at comparable dosages gave the following percentage mortality against marching armyworms in sorghum: 3 per cent DDT impregnated—96 per cent; 5 per cent DDT regular—92 per cent; and 3 per cent DDT regular—78 per cent. In addition, large scale emergency applications of a DDT spray at the rate of 2 lbs. of 50 per cent wettable powder per 40 gallons of water per acre gave satisfactory results on both corn and sorghum.

CONTROL IN GRASSLAND AND TRUCK CROPS.—The experimenal work referred to above had been directed against armyworms feeding in spots relatively inaccessible to insecticides, *e.g.*, the whorls of corn, etc. In many other crops grown in this area such as kale, collards, soybeans, alfalfa, etc. armyworm feeding occurs directly in the open or in places easily reached by dusts and sprays. This is par-

Table 2.—Comparison of impregnated and non-impregnated DDT dusts for armyworm control in sorghum. Oceana, Virginia. 1948.

Treatment	Lbs. Per Acre	Armyworms per Sq. Ft. After 48 Hours		
		Alive No.	Dead No.	Per Cent Dead
5% DDT—Regular	35–40	9	98	92
3% DDT—Regular	35–40	22	78	78
3% DDT—Impregnated	35–40	5	110	96
Untreated Check	—	122	0	0

Acknowledgement is made to the following companies for providing materials used in these tests: Chlordan—U. S. Rubber Co., Naugatuck Chemical Div.; DDT concentrates Gesarol AG-50 and Geigy VD-10, "Gytol" and impregnated methoxychlor—Geigy Co., Inc.; Improved Benzene Hexachloride—Dow Chemical Co.; Parathion—American Cyanamid and Chemical Corporation and Pennsylvania Salt Manufacturing Co.; "Rhothane" (DDD)—Rohm and Haas Co.; Tetraethyl pyrophosphate—Westvaco Chemical Corporation; and "Toxaphene"—Hercules Powder Company.

ticularly true of kale and collards when small, a condition often coinciding with the peak of the armyworm infestation.

Dust tests comparing 8 insecticidal treatments were conducted on pasture-land at Bayville Farms, Norfolk, Virginia. The grass had been clipped very short by the armyworms yet they were actively feeding. At the time of treatment populations averaged approximately 8.5 per square foot with practicallly all of the armyworms in the fifth and sixth instars. These conditions afforded an ideal situation for a comparative study of the various insecticides. All plats were 150 feet long by 20 feet wide and were replicated four times within randomized blocks. The materials were applied with a motor-driven, eight-nozzle, tractor-drawn duster equipped with a 25 foot cloth trailer. Treatments were made August 6 between 6:30 and 10:00 A.M. During this time the temperature ranged from 60° to 70° F, the relative humidity from 60 to 55 per cent, and the wind velocity from 6 to 12 miles per hour. Although the wind was rather gusty, it blew lengthwise over the plats and little cross drift resulted. Temperatures continued unseasonably cool during the next 24 hours.

Records were taken 24 hours after treatment. Ten samples, each 1 square foot in area, were selected at random from the various plats and the total number of living and dead armyworms therein counted. Forty-eight hour records are not presented as larval movement within plats and between adjacent plats confounded the value of such data.

The different materials tested, rates of application, and results obtained are given in table 3. All treatments resulted in a significant reduction in armyworm population. However, 2 per cent parathion, 3 per cent DDT impregnated and 5 per cent DDT regular were outstanding; these insecticides gave mortailities of 100, 99, and 98 per cent, respectively. The 1 per cent parathion dust with 86 per cent mortality and 5 per cent chlorinated camphene dust with 81 per cent mortality also showed promise. Five per cent chlordan, 1 per cent DDT—0.5 per cent parathion, and 20 per cent chlorinated camphene were considerably less effective than the aforementioned treatments.

It is of interest to note that the 1 per cent and 2 per cent parathion dusts, and the 1 per cent DDT—0.5 per cent parathion dust to some extent, killed large numbers of first and second instar Japanese beetle grubs which were feeding very close to the soil surface.

FURTHER TESTS ON PASTURES AND HAYFIELDS.—Although DDT dusts and sprays give excellent control of the fall armyworm, the residue left by this insecticide might create a serious problem in pasture lands and hayfields. On August 7, 1948 several closely clipped pastures in the Norfolk area were treated with DDT and the stock removed for 3 to 4 weeks to allow regrowth of the pasture and for weathering of the DDT. However, before the end of this period it was discovered that the new growth had become heavily infested with armyworms of the next generation. Obviously, it was highly desirable to devise control measures which would reduce the interval between insecticidal treatment and allow for early resumption of glazing through the use of materials considered to be safer than DDT or in reduced amounts of DDT.

Table 3.—Results of dust tests for control of the fall armyworm in pasture. Norfolk, Virginia. 1948.

Treatment	Lbs. per Acre of Insecticide	Number Armyworms per Sq. Ft.		
		Dead	Alive	Per Cent Dead
5% DDT—Regular	37	9.3	.2	98
3% DDT—Impregnated	38	9.0	.1	99
5% Toxaphene	34	7.2	1.7	81
5% Chlordan	39	5.3	3.2	62
1% DDT—0.5% Parathion	38	4.4	2.0	69
1% Parathion	41	8.0	1.3	86
2% Parathion	33	10.4	0.0	100
20% Toxaphene	10	4.6	2.6	64
Check	—	.1	6.5	2
Difference for significance (19:1 odds)				24

The following materials were tested (sprays). Tetraethyl pyrophosphate (40 per cent)—1: 400, 1: 800; piperonyl cyclonene (8 per cent)—pyrethrum (0.8 per cent)—1: 400, 1: 800; a water miscible sabadilla alkaloid concentrate—1: 400; 40 per cent nicotine sulphate—1: 400; and 50 per cent dichlorodiphenyldichloroethane wettable powder (dusts) 0.5 per cent DDT—0.06 per cent pyrethrins;[1] 1 per cent DDT—0.12 per cent pyrethrins;[1] 0.5 per cent piperonyl cyclonene—0.05 per cent pyrethrins; and 5 per cent dichlorodi-

[1] Formulated by mixing pyrethrum and DDT concentrates.

phenyldichloroethane. Tetraethyl pyrophosphate and DDD were the only materials showing promise of adequate control. Due to slight foliage injury to clover, tetraethyl pyrophosphate was eliminated from further consideration.

Large scale applications of dichlorodipheynyldichloroethane were made August 27 at the Bayville Farms. Twenty acres of grazing land were treated with dosages of 2 and 4 pounds of 50 per cent dichlorodiphenyldichloroethane wettable powder per 50 gallons of water per acre. At the time of treatment the armyworms were not beyond the third instar. Populations were extremely heavy averaging 35 to 50 per square foot. Observations at the end of 24 hours showed mortalities ranging from 98 to 100 per cent. A 5 per cent dichlorodiphenyldichloroethane dust applied at 40 lbs. per acre gave comparable results.

In view of the reduced toxicity of dichlorodiphenyldichloro ethane to warm blooded animals, substitution of this material for DDT or other equally toxic materials may permit a quicker resumption of grazing on treated pasture lands.

NATURAL CONTROL.—Normally the fall armyworm is held fairly well in check throughout most of its range by the operation of natural controls, chief among which are certain parasites and predators. As stated previously, damaging infestations in southeastern Virginia are usually limited to one generation. According to Luginbill (1928) severe general infestations are commonly associated with periods of cool, wet weather in areas in the south where the insect overwinters. Similar conditions along the route of northward migration are likewise conducive to rapid armyworm multiplication. Such favorable conditions occurred during 1948. In 1948 there were three well defined and damaging generations of armyworms in Virginia prior to September 1. Each generation was progressively more abundant and indices based on pasture lands indicated 1–2, 8–10, and 25–50 armyworms per square foot for the first, second, and third generations, respectively.

Predators were more or less active throughout the season and at times proved very effective in controlling localized infestations. An outstanding example of control by predators was noted near Oceana, Virginia, in late July. Several species of carabid larvae were instrumental in reducing armyworm populations in 39 acres of sorgum to such an extent that insecticidal treatment was unnecessary. Inspection revealed an average of 2 to 3 carabid lavvae per square foot. Representative samples of actively feeding carabid larvae were collected and reared for determination. Larvae of the fiery hunter, *Calosoma calidum* Fab., were found to comprise about 75 per cent of the total. Other ground beetle larvae present were *Calosoma scrutator* Fab., *Calosoma sayi* Def., and *Harpalus pennsylvanicus* Dej.

From time to time throughout the season numerous predators were observed. Some of these are as follows: Cicindelidae —*Tetracha carolina* L. and *Cincindela sexguttata* F.; Nabidae—*Nabis ferus* L.; Pentatomidae—*Posidsus maculiventris* Say; and several species of unidentified dragon flies and wasps. *Podisus maculiventris* Say appeared to rank next in importance to the *Calosoma* beetles.

Parasites did not cause marked reductions in armyworm populations until early September. Dipterous and hymenopterous parasites became so effective at that time as to eliminate the need of further control measures in many instances. Predominating in abundance were the Braconids, *Apanteles marginiventris* (Cress.) and *Apanteles* spp., and the Tachinid, *Winthemia rufopicta* Big.[1] Ten or more *Apanteles* cocoons per square foot were observed in pasture lands having an original armyworm population of approximately 25 per square foot. Parasitism by *Winthemia rufopicta* Big. and other undetermined species of Tachinids often exceeded 95 per cent of the remaining larvae. Unfortunately, secondary parasitism of the *Apanteles* was very common. Emergence records from *Apanteles* cocoons indicate that as high as 75 per cent were parasitized by a Pteromalid, *Eupteromalus viridescens* (Walsh). Other secondary parasites noted were as follows: Pteromalidae, *Catolaccus aeneoviridis* Gir.; Chalcididae, *Ceratosmicra meteori* Burks; and Ichneumonidae, *Mesochorus discitergus* (Say).

[1] The writers are indebted to members of the Division of Insect Identification, Bureau of Entomology and Plant Quarantine, U. S. Dept of Agriculture for identification of armyworm parasites.

DISCUSSION AND CONCLUSIONS.—DDT dusts and sprays were, for the most part, very effective in controlling fall armyworm damage in southeastern Virginia during 1948. Large acreages were treated with DDT at a rate of 2 lbs. of 50 per cent wettable powder per 40 gallons of water per acre or 25 to 40 lbs. of 3 per cent impregnated or 5 per cent straight mix dust. The degree of control varied from adequate to almost 100 per cent, depending on the crop, larval instar, type of equipment and thoroughness of application. Other things being equal, thoroughness of application appeared to be the most important single factor in control. In evaluating the effectiveness of any DDT treatment, the relatively slow toxic action of the non-impregnated formulations must be kept in mind. Armyworms receiving lethal dosages of DDT in this form will often leave the host plant and move to the soil or nearby refuse where they eventually die. These larvae were never observed to return to the plant or to resume active feeding. The inability of growers to find dead armyworms after DDT treatment has often directed their attention away from the ultimate objective, cessation of feeding and prevention of further injury to the crop.

A common cultural practice in this area consists of planting kale, collards and other crucifers in mid-to-late summer and harvesting at various periods throughout the fall, winter or spring. The tender young plants of these crops are very susceptible to Armyworm injury and may be destroyed in a short time. Despite the use of poison bran baits, considerable damage has occurred in the past. Cooperative control treatments with DDT dusts and sprays were applied on approximately 500 acres of kale and collards in 1948. Notwithstanding one of the heaviest infestations on record, damage by armyworms to DDT treated crops was negligible.

In addition to DDT, parathion and chlorinated camphene appear to offer definite possibilities for armyworm control. Parathion was the only insecticide tested that consistently killed armyworms deep within the buds of corn while chlorinated camphene was used successfully by a number of growers in this area. Benzene hexachloride dusts gave good results whenever tested and, if the taste factor can be eliminated, should prove a valuable addition to the materials now available.

Dichlorodiphenyldichloroethane sprays and dusts gave 98 to 100 per cent control of young armyworms on pasture lands. Armyworm control of this effectiveness together with the comparatively low mammalian toxicity of dichlorodiphenyldichloroethane appears to offer considerable promise in situations in which more toxic residues might prove objectionable or dangerous.

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LINDANE

The word lindane has been selected as the approved common name for the gamma isomer of benzene hexachloride of a purity of not less than 99 per cent. A complete description and other information will be published in the August issue of the JOURNAL.

Journal authors are urged to use the approved name in journal manuscripts from now on as it will be substituted for any other name used in all papers published in the JOURNAL as is required by a rule of the Association.

The announcement of the new name comes from Dr. S. A. Rohwer, Chairman, Interdepartmental Committee on Pest Control, as of June 25, 1949.

Field Experiments for Control of the Grape Berry Moth[1]

JAMES A. COX, *Pennsylvania Agricultural Experiment Station, State College, Pa.*

The grape berry moth, *Polychrosis viteana* Clem., is considered one of the major grape pests in the Erie Grape Belt and often causes severe damage to the grape crop. The accepted methods of control have been sprays of lead arsenate or calcium arsenate in the early part of the season, and fixed nicotine sprays for the latter part of the season, The control of the grape berry moth has received the attention of a number of workers in recent years. Hutson (1941) has shown that a schedule of two sprays of an arsenical with oil and two sprays of a fixed nicotine gave satisfactory control of the grape berry moth. Taschenberg & Hartzel (1942), working in New York, found that four arsenical sprays were more effective than a split schedule consisting of two sprays of an arsenical and two sprays of a fixed nicotine. However, to prevent excessive spray residue at harvest these workers recommend the use of nicotine late in the season. In Pennsylvania, Gleissner (1943) found that the arsenical sprays were more effective for the grape berry moth than a number of organic insecticides. However, if arsenical sprays were used late in the season the spray deposits at harvest were likely to be high.

In recent years DDT sprays have shown promise for the control of the grape berry moth. In New Jersey, Fleming & Maines (1947) have found that sprays of DDT were more effective for the grape berry moth than sprays of lead arsenate. In New York, Taschenberg (1948) has conducted experiments on the control of the grape berry moth and has shown that three sprays of DDT will satisfactorily control this pest.

Although the arsenical sprays have been satisfactory in a number of vineyards for the control of the grape berry moth, their use has been restricted to the early part of the season. In view of this, experiments were started in 1944 to test some of the newer organic insecticides, and to compare their effectiveness with the standard treatment for the control of the grape berry moth. This paper gives a summary of the results for 1944 to 1948.

METHODS AND MATERIALS.—The experiments were conducted in commercial vineyards in the vicinity of North East, Pa. The vineyards were located on gravely soils and were planted to the variety Concord. The vines were trained to the umbrella system. The tests were performed only in vineyards that had been in previous years heavily infested with the grape berry moth. The test plots were five rows wide and 15 to 24 vines long during the seasons of 1944 to 1946. In 1947 and 1948 the test plots were four rows wide and 18 to 24 vines long. Each year the plots were replicated four times and the positions of the plots within the blocks were left to chance.

At harvest time ten count vines (excluding the three end vines) were selected at random from the inside rows of each plot. Ten clusters of grapes were taken from each of the ten vines and a record made of the number of clean and infested berries on each cluster. The results were converted to a percentage basis and the per cent control was calculated according to the formula of Abbott (1925).

The sprays were applied with a power sprayer and a covered, inverted, U-shaped boom carrying from five to seven nozzles on each side of the row and so arranged that the spray from the nozzles was directed upwards and into the foliage and clusters of the vine. From 175 to 225 gallons of spray materials were used to the acre. The sprays were applied at a pressure ranging from 450 to 500 pounds per square inch.

In the test vineyards the emergence and flight of the grape berry moth was timed with emergence cages and bait traps. The bait traps were charged with a solution made of dark brown sugar and water (one pound of sugar and water to make one gallon). To each quart of the sugar solution was added one cubic centimeter of oil of sassafras. The fermenting lure was suspended, in wide-mouth glass quart fruit jars, from the top trellis wire. The emergence cages (Fig. 1) were

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Table 1.—Summary of results of experiments for grape berry moth in vineyard A. 1944.

Test No.	Material and Amounts per 100 Gallons[1]	Applications	Per Cent	
			Infested Berries	Control
1	Lead arsenate, 3 lbs. Nicotine sulphate, 12 oz. Fixed nicotine, 3 lbs.	1st, 2nd and 3rd 1st and 2nd 4th	1.4	92.0
2	Lead arsenate, 3 lbs. Nicotine sulphate, 12 oz. Fixed nicotine, 3 lbs.	1st and 2nd 1st and 2nd 3rd and 4th	3.2	81.8
3	DDT, 0.6 lb.	1st, 2nd, 3rd and 4th	1.2	93.1
4	Lead arsenate, 3 lbs. Nicotine sulphate, 12 oz. Lead arsenate, 2 lbs. Phenothiazine, 2 lbs.	1st and 2nd 1st and 2nd 3rd and 4th	4.3	75.5
5	Check, not sprayed		17.6	—

[1] Bordeaux mixture 2-2-100 was used in the first and second sprays in all the treatments. A miscible oil was used at the rate of 3 quarts to 100 gallons in all the treatments.

made of strips of wood and covered with screen wire and were placed over the grape vine. The bait traps and emergance cages were entirely satisfactory for securing information on the flight of the grape berry moth.

The insecticides used in the experiments were as follows: nicotine sulphate,[2] 40 per cent nicotine; a fixed nicotine,[3] containing 14 per cent nicotine; a miscible oil,[4] viscosity 100 seconds Saybolt at 100° F.; an oil base spreader;[5] a miscible oil,[6] viscosity 53 seconds Saybolt at 100° F. unsulfonable residue 93 per cent; an oil soluble emulsifying agent;[7] lead arsenate, an unconditioned commercial product containing 19.5 per cent metallic arsenic and 58 per cent metallic lead; a wettable powder,[8] containing 20 per cent, 40 per cent and 50 per cent DDT respectively; a wettable powder,[9] containing 40 per cent DDT; an emulsifiable product,[10] containing 25 per cent DDT; a wettable powder,[11] containing 50 per cent dichlorodiphenyl dichloroethane; a processed material,[12] derived from plants of the genus *Ryania;* benzene hexachloride,[13] a wettable powder containing 6 per cent of the gamma isomer; a wettable powder,[14] containing 48 per cent sabadilla seed; a wettable powder,[15] containing 15 per cent and 25 per cent parathion; phenothiazine, a micronized unconditioned product that was water pasted with lead arsenate; a wettable powder,[16] containing 50 per cent chlordan; a wettable powder,[17] containing 25 per cent chlorinated camphene.

Field Experiments.—In 1944 experiments were conducted in two commercial vineyards. Table 1 gives a list of the treatments and a summary of the results of the tests performed in vineyard A. The spray dates are as follows: First spray June 22, second spray June 30, third spray July 7 and the fourth spray August 3. The results indicate that four sprays of DDT were quite effective for the grape berry moth and appeared to be as effective as lead arsenate in controlling this insect. Two sprays of lead arsenate and two applications of a fixed nicotine (test no. 2) and a mixture of lead arsenate and phenothiazine (test no. 4) did not satisfactory control the grape berry moth.

In vineyard B the tests were conducted to secure information on the value of a pre-blossom spray for the control of the

[2] *Black Leaf 40.* Tobacco By-Products and Chemical Co., Richmond, Va.
[3] *Black Leaf 155.* Tobacco By-Products and Chemical Co., Richmond, Va.
[4] *Sunoco.* Sun Oil Co., Philadelphia, Pa.
[5] *Orthex.* California Spray-Chemical Corp., Richmond, Calif.
[6] Ninety per cent oil and 10 per cent *Triton B-1956.*
[7] *Triton B-1956.* Rhom and Haas Co., Philadelphia, Pa.
[8] *Gesarol AK-20, Gesarol AK-40* and *Gesarol AK-50.* Geigy Co., Inc. New York, N. Y.
[9] *Gesarol AKZ-40.* Geigy Co., Inc. New York, N. Y.
[10] *Gesarol E-25.* Geigy Co., Inc. New York, N. Y.
[11] *Rhothane.* Rhom and Haas Co., Philadelphia, Pa.
[12] *Ryania.* Merck and Co., Rahway, N. J.
[13] *Gamtox.* California Spray-Chemical Corp., Richmond, Calif.
[14] *Sabacide.* McConnon and Co., Winona, Minn.
[15] *Thiophos 3422.* American Cyanamid Co., New York, N. Y.
[16] *Dow Klor.* Dow Chemical Co., Midland, Mich.
[17] *Toxaphene.* Hercules Powder Co., Wilmington, Del.

Table 2.—Summary of results of experiments comparing pre-blossom and post blossom sprays for the grape berry moth in vineyard B. 1944.

Test No.	Material and Amounts per 100 Gallons[1]	Applications	Per Cent	
			Infested Berries	Control
1	Lead arsenate, 3 lbs. Nicotine sulphate, 12 oz. Fixed nicotine, 3 lbs.	1st, 2nd, 3rd & 4th 2nd & 3rd 5th	4.9	77.8
2	Lead arsenate, 3 lbs. Nicotine sulphate, 12 oz. Fixed nicotine, 3 lbs.	2nd, 3rd & 4th 2nd & 3rd 5th	4.6	79.2
3	Check, not sprayed		22.2	—

[1] Bordeaux mixture 2-2-100 was used in all the treatments in the first, second and third sprays. A miscible oil was used at the rate of 3 quarts to 100 gallons in all the treatments.

grape berry moth. The spray dates were as follows: First spray June 9, second spray June 19, third spray June 27, fourth spray July 12 and the fifth spray August 18. A list of the treatments and a summary of the results are shown in table 2. The treatments were identical except that test no. 1, received one spray of lead arsenate before the grapes bloomed. The results indicate that in 1944 a pre-blossom spray of lead arsenate did not increase the efficiency of the spray program.

Preliminary experiments in 1944 indicated that sprays of DDT were quite effective for the grape berry moth. In 1945, in order to secure information on the following pressing questions, tests were conducted in four commercial vineyards: Is it possible to control the grape berry moth with DDT sprays? And if so, how many applications of DDT are necessary? And is it possible to control the grape berry moth with a shortened intensive spray program?

A list of the treatments in vineyard A are shown in table 3. The sprays were applied on the following dates: First spray June 27, second spray July 9, third spray July 24 and the fourth spray August 29. A summary of the results are given in table 3. The results indicate that either three or four sprays of DDT were as effective as lead arsenate for the control of the grape berry moth. Three sprays of DDT appeared to be equally as effective as four sprays of this material. Two sprays of DDT (test no. 6) did not effectively control the grape berry moth.

The large plot experiments were conducted in three vineyards comparing lead arsenate and DDT in a two spray program. Each vineyard received two applications of spray. The first was applied just after the berries set and the second spray was applied when the berries touched in the clusters. The conventional or so-called 10 day spray was omitted. The entire vineyards were sprayed and approximately 200 gallons of spray was applied at each application per acre. At harvest time 100 clusters of grapes were collected from 10 vines and examined for clean and infested berries. The counts were made at six locations in each vineyard. A summary of the results are shown in table 4. The results from the large plots indicate that two sprays of DDT were quite effective for the grape berry moth. While no unsprayed checks were available for comparison it should be pointed out that the grapes in a neglected vineyard adjacent to vineyard B were 19.8 per cent infested.

As one will readily note the results of the large plot experiments (table 4) are not entirely in agreement with the data in the small plot tests (table 3, test no. 6). However, it should be pointed out that the spray program in vineyard A (test no. 6) called for the first two sprays, whereas in vineyards B and C the spray schedule followed was the first and third applications of spray. The second spray or 10 day application was omitted.

During the season of 1946 experiments were conducted in two vineyards. Table 5 gives a list of the treatments and a summary of the results in vineyard A. The sprays were applied on the following dates: First spray June 28, second spray July 8, third spray July 24 and the fourth spray August 26. There was a very light

Table 3.—Summary of results of experiments for grape berry moth in vineyard A. 1945.

Test No.	Material and Amounts per 100 Gallons[1]	Applications	Per Cent	
			Infested Berries	Control
1	Lead arsenate, 3 lbs. Nicotine sulphate, 12 oz. Fixed nicotine, 3 lbs.	1st, 2nd & 3rd 2nd 4th	3.5	89.0
2	Lead arsenate, 3 lbs. Nicotine sulphate, 12 oz. Fixed nicotine, 3 lbs.	1st & 2nd 2nd 3rd & 4th	7.6	76.2
3	Lead arsenate, 3 lbs. Nicotine sulphate, 12 oz. Lead arsenate, 1.5 lbs. Phenothiazine, 2 lbs. Spreader, 16 oz.	1st & 2nd 2nd 3rd & 4th	5.7	82.2
4	DDT, 0.8 lb.	1st, 2nd, 3rd & 4th	0.93	97.1
5	DDT, 0.8 lb.	1st, 2nd & 3rd	1.6	95.0
6	DDT, 0.8 lb.	1st & 2nd	9.6	70.0
7	DDT, 0.8 lb. Lead arsenate, 3 lbs.	1st & 2nd 3rd	3.9	87.8
8	DDT, 0.8 lb. Spreader, 12 oz.	1st, 2nd, 3rd & 4th	0.84	97.3
9	*Ryania*, 6 lbs. Nicotine sulphate, 12 oz.	1st, 2nd, 3rd & 4th 2nd	12.5	60.9
10	DDD, 1 lb.	2nd, 3rd & 4th	5.3	83.4
11	Check, not sprayed		32.0	—

[1] Bordeaux mixture 2-2-100 was used in the first and second sprays in all the treatments and in the third spray in treatments nos. 1 and 7. A miscible oil was used at the rate of 2 quarts to 100 gallons in all the treatments except test no. 8 and in the third and fourth sprays in test no. 3.

infestation of grape berry moth in vineyard A during the season of 1946. The unsprayed check was only 7.4 per cent infested. Due to the light infestation very little information was secured on the control of the grape berry moth in 1946.

In vineyard B one application of sprays was applied on July 19 for grape leafhopper. The plots were 10 rows wide and 70 vines long. The treatments were not replicated. Observations two weeks before harvest indicated that one application of spray greatly reduced the grape berry moth infestation on some of the treatments. At the time the grapes were harvested counts were made on the treated area and the results are summarized in table 6. The results indicate that one application of DDT at the rate of 0.5 pound to 100 gallons gave a decided reduction in the grape berry moth population. DDD at 0.25 pound and benzene hexachloride at 3 pounds to 100 gallons gave little control of the grape berry moth. While it is recognized that the schedule followed in vineyard B is not adequate to control the grape berry moth it is interesting to note that DDT, at reduced dosages of 0.5 and 0.25 pound to 100 gallons, gave a decided reduction in the number of berries infested by this insect.

Table 4.—Results of large plot experiments for grape berry moth 1945.

Vineyard	Material and Amounts per 100 Gallons[1]	Date of Application	Per Cent Infested Berries	Acres Treated
B	DDT, 0.8 lb.	June 27 July 24	1.2	15
C	DDT, 0.8 lb.	June 26 July 23	4.4	8
D	Lead arsenate, 3 lbs. Nicotine sulphate, 12 oz.	June 23 July 22	8.3	8

[1] Bordeaux mixture 2-2-100 was used in all the treatments. A miscible oil was used at the rate of 2 quarts to 100 gallons.

The experiments in 1947 were conducted in a vineyard that was heavily infested with the grape berry moth. The sprays were applied on the following dates: First spray June 30, second spray July 10, third spray August 3 and the fourth spray

Table 5.—Summary of results of experiments for grape berry moth in vineyard A. 1946.

Test No.	Material and Amounts per 100 Gallons[1]	Applications	Per Cent	
			Infested Berries	Control
1	Lead arsenate, 3 lbs. Nicotine sulphate, 12 oz.	1st, 2nd & 3rd 1st & 2nd	1.2	83.7
2	DDT, 0.75 lb. Lead arsenate, 3 lbs.	1st & 2nd 2nd	0.74	90.0
3	DDT, 0.75 lb.	1st & 3rd	0.64	91.3
4	DDT, 0.75 lb.	1st, 2nd & 3rd	0.51	93.1
5	DDT, 0.75 lb.	1st, 2nd. 3rd & 4th	0.10	98.6
6	Benzene hexachloirde, 3 lbs.	1st, 2nd & 3rd	1.60	78.3
7	DDD, 0.75 lb.	1st, 2nd, 3rd & 4th	0.20	97.2
8	DDD, 0.75 lb.	1st, 2nd & 3rd	0.27	96.3
9	*Sabacide*, 6 lbs.	1st, 2nd, 3rd & 4th	1.90	74.3
10	Check, not sprayed		7.4	—

[1] Bordeaux mixture 2-2-100 was used in all the treatments in the first, second and third sprays. A light summer miscible oil was used at the rate of 2 quarts to 100 gallons in all the treatments.

August 22. A list of the treatments and a summary of the results are given in table 7. As may be seen in table 7 DDT in three and four applications of spray gave excellent control of the grape berry moth. Two applications of DDT applied in the first and third sprays was equally as effective as lead arsenate and fixed nicotine. DDD appeared to be as effective as DDT for the control of this pest. Chlordan did not appear to give satisfactory control of the grape berry moth and three applications of this material severely burned the grape foliage. Two sprays of toxaphene severely burned the grape foliage and no further applications were made. One plot of grapes, four rows wide and 75 vines long, was sprayed with parathion. At harvest time counts were made at four locations in the treated area and the results indicate that this material was quite effective for the control of the grape berry moth.

In 1948 further experiments were carried out with DDT, lead arsenate, DDD and parathion for the grape berry moth. The sprays were applied on the following dates: First spray June 30, second spray July 12, third spray August 10 and the fourth spray August 20. A list of the treatments are shown in table 8. DDT gave excellent control of the grape berry moth when used in three or four sprays. Two applications of DDT applied in the first and second sprays did not satisfactorily control the grape berry moth. Three applications of DDD gave excellent control of the grape berry moth and the results indicate that this material is as effective as DDT for the control of this insect. As may be seen in table 8 three applications of parathion gave excellent control of the grape berry moth.

Table 6.—Results of one application of spray for the grape berry moth in vineyard B. 1946.

Test No.	Material and Amounts per 100 Gallons[1]	Per Cent	
		Infested Berries	Control
1	DDT, 0.5 lb.	5.8	87.9
2	DDT, 0.25 lb.	14.5	71.3
3	DDD, 0.25 lb.	26.9	44.1
4	Benzene hexachloride, 3 lbs.	27.9	42.1
5	Check, not sprayed	48.2	—

[1] Bordeaux mixture 2-2-100 was used in all the treatments A light summer miscible oil was used at the rate of 3 pints to 100 gallons.

SPRAY RESIDUE.—Since grapes are used either as fresh fruit or processed into grape juice, the spary residue on the harvested fruit is of considerable concern to the grape grower and to the processors of grape juice and other grape products. Each year residue analyses have been made on the harvested fruit from the DDT sprayed grapes and from some of the grapes sprayed with lead arsenate.

A summary of the results is shown in table 9. While it will not be necessary to discuss the relative merits of the various treatments it should be pointed out that DDT, used with an oil and in four applications of spray, is likely to produce a high residue at harvest. When used without an oil, four sprays containing the same amount of DDT did not produce such high residues (plot no. 7) at harvest. The results indicate that DDT can be used with a light summer oil in three

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Table 7.—Summary of results of experiments for the grape berry moth. 1947.

Test No.	Material and Amounts per 100 Gallons[1]	Applications	Per Cent	
			Infested Berries	Control
1	Lead arsenate, 3 lbs. Nicotine sulphate, 12 oz. Fixed nicotine, 3 lbs.	1st, 2nd & 3rd 2nd 4th	5.1	82.6
2	DDT, 0.75 lb.	1st & 3rd	4.6	84.3
3	DDT, 0.75 lb.	1st, 2nd & 3rd	2.6	91.3
4	DDT, 0.75 lb.	1st, 2nd, 3rd & 4th	1.3	95.5
5	DDD, 0.75 lb.	1st, 2nd, 3rd & 4th	2.5	91.1
6	Chlordan, 0.75 lb.	1st, 2nd & 3rd	13.8	53.0
7	Toxaphene, 3 lbs. DDD, 0.75 lb.	1st & 3nd 3rd	9.9	65.9
8	Parathion, 0.45 lb. Spreader, 4 oz.[2]	1st, 2nd, 3rd & 4th	0.15	99.4
9	Check, not sprayed		29.4	—

[1] Bordeaux mixture 2-2-100 was used in all the treatments except treatment no. 8 and was omitted in the fourth spray of test no. 1. A light miscible summer oil was used at the rate of 3 pints to 100 gallons. In test no. 8 ferric dimethyldithiocarbamate (*Fermate*) was used at the rate of 1.5 pounds to 100 gallons.
[2] *Triton B-1956.*

sprays without an excessively high residue at harvest (Plots 10 and 16). Lead arsenate used with an oil and in three applications produced residues well over the legal tolerance on harvested fruit.

As a major portion of the grape crop is processed into grape juice it might be of interest to point out that Frear & Cox (1946) have shown that grape juice contained no DDT made from grapes that had been sprayed with four applications of DDT (residue on the fruit 0.142 grains of DDT per pound of fruit). The DDT appears to be concentrated in the pomace, as these workers have shown that this product contained 1.15 grains of DDT per pound.

DISCUSSION AND SUMMARY.—The data presented in tables 1 to 8 indicate that DDT used at the rate of 0.75 pound per 100 gallons and in three sprays will satisfactorily control the grape berry moth. In heavily infested vineyards three applications of DDT appear to be as effective as four applications. Field experiments indicate that DDT was more effective for the grape berry moth than a combination spray of lead arsenate and nicotine sulphate. In heavily infested vineyards two applications of DDT, when applied in the

Table 8. Summary of results of experiments for the grape berry moth. 1948.

Test No.	Material and Amounts per 100 Gallons[1]	Applications	Per Cent	
			Infested Berries	Control
1	DDD, 0.75 lb.	1st, 2nd & 3rd	1.10	96.1
2	Parathion, 0.25 lb.	1st, 2nd & 3rd	2.90	89.8
3	DDT, 0.75 lb.	1st & 2nd	9.70	66.2
4	DDT, 0.75 lb.	1st, 2nd & 3rd	0.95	96.6
5	DDT, 0.75 lb.	1st, 2nd, 3rd & 4th	0.44	98.4
6	DDT(emulsifiable), 32 oz.	1st, 2nd & 3rd	2.20	92.3
7	Lead arsenate, 3 lbs. Nicotine sulphate, 12 oz.	1st, 2nd & 3rd 1st & 2nd	1.90	93.3
8	Parathion, 0.25 lb.	1st, 2nd & 3rd	0.63	94.3
9	Check, not sprayed		28.70	—

[1] Bordeaux mixture 2-2-100 was used in all the treatments except test no. 2. In test no. 2 ferric dimethyl dithiocarbamate (*Fermate*) was used at 1.5 pounds to 100 gallons. A miscible light summer oil was used at the rate of 3 pints to 100 gallons in all the treatments except test nos. 2 and 6.

Table 9.—Summary of DDT and Lead residues on grapes from experimental plots. 1944 to 1947.[1]

Year	Plot No.	Material and Amounts per 100 Gallons[2]	No. Sprays	PPM	
				DDT	Lead
1944	1	DDT, 0.6 lb.	4	4.34	
1945	2	Lead arsenate, 3 lbs.	3		14.00
	3	Lead arsenate, 3 lbs.	2		
		DDT, 0.8 lb.	1	1.64	4.34
	4	DDT, 0.8 lb.	4	19.88	
	5	DDT, 0.8 lb.	3	10.39	
	6	DDT, 0.8 lb.	2	1.64	
	7	DDT, 0.8 lb.			
		Spreader, 12 oz.	4	7.89	
	8	Check, not sprayed	—	0.00	0.00
1946	9	DDT, 0.75 lb.	4	5.3	
	10	DDT, 0.75 lb.	3	3.1	
	11	DDT, 0.75 lb.	2	2.6	
	12	DDT, 0.75 lb.	2		
		Lead arsenate, 3 lbs.	1	3.7	4.4
	13	Lead arsenate, 3 lbs.	3		13.00
	14	Check, not sprayed		1.1	0.00
1947	15	DDT, 0.75 lb.	2	7.6	
	16	DDT, 0.75 lb.	3	8.0	
	17	DDT, 0.75 lb.	4	9.4	
	18	Check, not sprayed	—	2.2	0.00

[1] The DDT and lead determinations were made by Dr. D. E. H. Frear, Dept. of Agricultural and Biological Chemistry, Pennsylvania State College, State College, Pa.

[2] Bordeaux mixture 2-2-100 was used in all the treatments. A miscible oil was used at the rate of 3 quarts to 100 gallons in 1944 and at the rate of 2 quarts to 100 gallons in 1945. In 1946 and 1947 a miscible light summer oil was used at 3 pints to 100 gallons.

first and second sprays, did not effectively control the grape berry moth. However, two applications of DDT, applied in the first and third sprays, gave satisfactory control of this pest. The grape growers of the Erie Grape Belt have used the last mentioned schedule for the seasons of 1946, and 1947 and 1948 and have had excellent control of the grape berry moth. The first spray is applied soon after the berries set and the second application is made about the time the berries touch in the cluster. Even though two sprays of DDT appear to give satisfactory control of the grape berry moth field tests indicate that it would be advisable, in heavily infested vineyards, to apply three sprays of DDT for at least one season. After the grape berry moth population has been reduced to a low level two sprays of DDT should give ample protection. DDD has given excellent control of the grape berry moth and the results indicate that this material is as toxic as DDT to this pest. The experiments for two seasons indicate that parathion is quite effective for the grape berry moth. However, further tests will be necessary to finally establish the value of this material for grape sprays. No injury to the fruit or foliage of the Concord grape has been observed where sprays of DDT, parathion and DDD were used. The following materials did not appear to be effective for the grape berry moth: Phenothiazine, benzene hexachloride, toxaphene and chlordan. It will not be necessary to discuss the relative merits of the above materials. However, it should be pointed out that grapes sprayed with benzene hexachloride were not suitable for fresh fruit or for processing into grape juice. Sprays of toxaphene and chlordane severely burned the foliage of the Concord grape.

The spray residue at harvest is likely to be high on grapes that have been sprayed with four applications of DDT, at the rate of 0.75 pound to 100 gallons, and an oil. While no legal tolerance has been established for DDT residues on grapes, the

residues remaining from three applications of DDT at the rate of 0.75 pound to 100 gallons are approximately in the same limits as those permitted for lead. Two sprays of DDT leaves a residue at harvest well under the present limits of 7 PPM for lead. Since a majority of the vineyards in the Erie Grape Belt receive only two applications of DDT it is not likely that the spray residue, on grapes from the commercial vineyards in this area, would be of major importance.

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Chlordan and Benzene Hexachloride for Control of Plum Curculio on Peach

S. C. CHANDLER, *State Natural History Survey, Carbondale, Illinois*

During the seasons of 1947 and 1948 chlordan and benzene hexachloride were tested in comparison with lead arsenate for the control of the plum curculio, *Conotrachelus nenuphar*. Methods of evaluating results differ from those commonly used in experimental work with this insect. A study of published and unpublished reports available indicates data are largely obtained from replicated laboratory and small plot tests. Comparative efficiency is based quite largely upon emergence of larvae from drop peaches and mortality of adults in cage tests. Infestation at harvest is sometimes given, with the explanation that it is influenced by nearby plots and treatment of the orchard outside the plots. In Illinois we have attempted to overcome some of these difficulties and the following report should be considered both a record of results with certain organic insecticides on peach and a presentation of a method of obtaining these records.

Following and during laboratory-field tests at Urbana, large scale experiments were conducted in the commercial peach-growing section of southern Illinois in six orchards in 1947 and in seven in 1948. Tests were purposely located over a territory extending 140 miles north and south and 40 miles east and west. In most cases orchards with heavy curculio infestation the previous year were selected. Spraying and dusting were done by grower cooperators who could be trusted, but as much supervision as possible was given. Plot size varied with topography, especially in the Ozark hill area, and with the grower's equipment and ability to cooperate. The goal was at least 100 trees in spray plots or sometimes the number of trees that could be covered by one spray tank of material. With dust blocks the goal was 200 trees or the number that could be covered with a 100-lb. sack of dust. Some replication was possible within orchards, but in general this was obtained by combining results from similar treatments in the various orchards. It was not possible, however, to run exactly the same tests in all cases in every orchard. It was found possible, because of close similarity of results, to obtain replication within certain individual orchards, by combining data from lead arsenate spray and dust plots, chlordan wettable powder and emulsion, and two brands of benzene hexachloride dust.

Data were obtained mainly by three methods: Thorough and systematic jarring throughout the season, collecting and examining drop fruit, and cutting and examining fruit at harvest. In addition,

preliminary infestation records were taken and observations on condition of fruit made throughout the season.

The materials used in the 1948 tests, all commercial products, and the dosages used, were as follows:

Benzene hexachloride.
- Wettable powder, containing approximately 50% technical benzene hexachloride and reported to contain 6% gamma isomer, dosage 3 lbs./100 gallons.
- Wettable powder, refined, 12% gamma isomer, with other isomers removed, dosage 1.5 lbs./100 gallons.
- Dust, 1% gamma isomer, dosage approximately 0.5 lb. per tree.
- Dust, 1% gamma isomer, refined, with other isomers removed, dosage 0.5 lb. per tree

Chlordan
- Wettable powder, 40 per cent active ingredient, dosage 1 lb. actual per 100 gallons, except in certain plots, where dosage was 0.5 lb. actual per 100 gallons.
- Miscible emulsion, 40 per cent active, dosage 1 lb. actual per 100 gallons.
- Dust, 5 per cent active ingredient.

Lead arsenate, acid
- Wettable powder, 3 lbs. per 100 gallons.
- Dust, 10 per cent, dosage 0.5 lb. per tree.

Recommended fungicides and safeners were included. All dusts were made with 5 per cent oil incorporated, except where manufacturers found less amounts necessary with organic insecticides for best physical delivery. Seven applications were made at 7- to 10-day intervals in five orchards, six in another, and ten in one receiving benzene hexachloride dust only. In one orchard these spray intervals were doubled in length in alternate blocks for part of the testing period, and are listed as "skip time" in the accompanying tables. All applications were started when shucks were splitting in April and extended into June and were directed against the overwintering beetles. This will be referred to as the "first-brood period." For taste tests a few individual trees were sprayed into what is termed in the tables the "second-brood period" when first generation adults were active. This extended from late June till harvest in August. In the second brood period one or more lead arsenate applications were made in all plots alike by the growers. In 1947 there were fewer treatments. Benzene hexachloride 6 per cent gamma wettable powder was used at rates from 2 to 4 lbs. per 100 gallons and a dust 0.9 per cent gamma, at 0.5 lb. per tree. Chlordan in emulsion form was used at 1 lb. actual per 100 gallons and in one orchard as a 5 per cent dust.

Jarring was done at approximately weekly intervals throughout the entire season in five representative trees in each block, using two 6 by 9 ft. sheets, one on either side of the trunk, making one placing only of the sheets per jarring. The mass of data obtained in 1948 has been condensed, where possible combined, and summarized in table 1. Total numbers in each treatment in each orchard are given and efficiency expressed in ratios of numbers of beetles jarred in the lead arsenate treated blocks to the others. The table is divided so beetles jarred from the trees in the first and second brood periods are given separately. The fewer numbers and higher ratios with the chlordan and benzene hexachloride treatments found in the second brood period is evidence that many failed to emerge from fruit treated with these materials, since presumably the adults found in the second brood period are descendants of those jarred in the first. The relatively larger ratios in the second brood period as compared with the first were observed both in 1947 and 1948 and are shown in tables 1 and 2. It is also apparent that this increase in ratio is greater with benzene hexachloride treatments than with those receiving chlordan. Thus in Table 1 chlordan every time, 1 lb./100, increases in ratio from 6.5 in the first brood to 10.2 in the second, and the 6 per cent gamma from 1.5 to 4.5 with a still greater increase in the case of benzene hexachloride technical grade dust of from 1.6 to 7.4 This indicates that more of the value of benzene hexachloride in large-orchard treatments lies in its ability to kill larvae in drop peaches than to kill the beetles which produce these larvae. It also indicates that chlordan kills a larger per cent of the overwintering curculios than does benzene hexachloride. This was further evidenced by the fact that there were fewer stung peaches in the chlordan blocks.

Table 1 also seems to indicate the following: Lengthening the interval between sprays reduced the efficiency, more so with benzene hexachloride than with chlordan. Reducing the dosage of chlordan from 1 lb. to 0.5 lb. per 100 gallons reduced the efficiency. The refined benzene hexachloride spray and dust treatments were inferior to the technical. Technical ben-

Table 1.—Plum curculio jarring, 1948. Totals from five trees with ratios of lead arsenate to other materials.

		Chlordan 0.5								Benzene Hexachloride Spray[3] .18 Lbs. Gamma per 100 Gallons						Benzene Hexachloride Dust			
		1 Lb. Every Time		1 Lb. Skip Time		0.5 Lb. Every Time		Dust 5%		Technical Grade Every Time		Technical Grade Skip Time		Refined Product		Dust (Technical)		Refined	
Orchard	Leads Ars.	T.[1]	R.[2]	T.	R.	T.	R.	T.	R.	T.	R.	T.	R.	T.	R.	T.	R.	T.	R.
First Brood Period																			
Beauman	183	15	12.2					278	.6	118	1.4			158	1.1	241	.7		
Connel	60	7	8.6	15	4.0	17	3.5	19	3.2	30	2.0	74	.8	68	.9	17	3.5	15.0	4.0
Fred Heaton	171	104	1.7	85	2.0					171	1.0	183	.9						
Lindorf Heaton	163	45	3.6			68	2.4			112	1.4								
Broom	114							56	2.0							93	1.2	78.0	1.4
Sauer	419							338	1.2							301	1.4	205.0	2.0
Ave. of ratios			6.5		3.0		2.9		1.7		1.5		.8		1.0		1.6		2.5
Second Brood Period																			
Beauman	143	8	17.9					72	2.0	20	7.1			21	7.1	8	17.8		
Connel	88	21	4.2	40	2.2	26	3.4	21	4.2	20	4.5	33	2.6	77	1.1	30	2.9	31.0	2.8
Fred Heaton	158	16	9.9	13	12.1					37	4.3	71	2.2						
Lindorf Heaton	89	10	8.9			35	2.5			46	1.9								
Broom	88							18	3.1							18	4.9	20.0	4.4
Sauer	370							200	1.8							98	3.9	141.0	2.6
Ave. of ratios			10.2		7.0		2.9		2.8		4.5		2.4		4.1		7.4		3.3

[1] T. = Total no. curculios jarred.
[2] R. = Ratio of lead arsenate to other materials.

zene hexachloride dust was somewhat superior to the spray, but chlordan dust dust was surprisingly inferior to the spray.

Drop peach collections were made from four to six times during the dropping period from five representative trees in every block. A drop peach was classed as "wormy" if a larva was found in it or if a larval tunnel extended into it for any appreciable distance. Percentages of wormy drops are given in table 3. The relatively high percentages of damaged fruits found in the chlordan- and benzene hexachloride treated plots as compared with those in the lead arsenate plots are somewhat out of line with the jarring and final infestation data in 1948 and with the results obtained in 1947 which are summarized in table 2. This may indicate considerable egg laying before early treatments had become effective and much tunneling before the larvae were killed.

The comparatively low percentage of wormy drops in the benzene hexachloride

Table 2.—A summary of 1947 tests with plum curculio showing effectiveness in terms of ratios, lead arsenate to chlordan and benzene hexachloride.[1]

Treatments	Ratio of Curculios Jarred		Ratios of	
	1st Brood	2nd Brood	Per Cent Wormy Drops	Per Cent Fruit Wormy at Harvest
Benzene hexachloride spray Technical grade 6% gamma 2 to 4 lbs. per 100 gal.	1.6[1]	3.0	5.5	2.1
Benzene hexachloride dust 0.9% gamma Technical grade	1.3	3.2	2.1	3.0
Chlordan spray 1 lb. per 100 gal.	6.4	5.1	3.7	3.5
Chlordan dust, 5% (one test only)	1.9	3.8	2.4	9.0

[1] Ratio example: Jarring records first brood period—lead arsenate 255 curculios; benzene hexachloride spray 15.8; ratio 1.6 to 1.

Table 3.—Per cent of drops wormy from plum curculio and oriental fruit moth.

Orchard	Lead Arsenate	Chlordan				Benzene Hexachloride Spray			Benzene Hexachloride Dust	
		1 Lb. Every Time	1 Lb. Skip Time	0.5 Lb. Every Time	Dust 5%	Every Time	Skip Time	Refined	Technical	Refined
Plum Curculio										
Beauman	54.1	16.8			32.8	30.7		23.7	7.8	
Broom	12.7				6.0				14.2	4.1
Connel	38.7	14.1	18.1	21.8	12.2	14.5	49.5	47.1	4.9	14.3
Fred Heaton	75.8	51.6	55.2			36.5	58.9			
Lindorf Heaton	81.2	54.0		36.8		48.7				
Sauer	59.7				60.9				37.9	50.0
Ave.	53.7	34.1	36.7	29.3	28.0	32.6	54.2	35.4	16.2	22.8
Oriental Fruit Moth										
Beauman	0	3.5			.2	6.3		4.2	.9	
Broom	2.6				1.2				.8	.3
Connel	1.4	2.3	1.8	1.2	.2	2.7	6.4	7.8	0	.2
Fred Heaton	1.4	12.9	9.1			16.5	10.9			
Lindorf Heaton	1.8	18.9		26.6		19.1				
Sauer—Old Orchard	.5				2.7				5.5	
Sauer—Young Orchard	8.3 (near apples)								6.3	.5
Ave.[1]	1.3	9.4	5.5	13.9	1.1	11.2	8.7	6.0	1.8	.3

[1] Except Sauer young orchard.

technical grade dust, as shown in table 3, is possibly significant when considered with the high average second-brood jarring ratio and the final infestation data given in table 4.

Table 4 summarizes the final infestation data. These data agree fairly well with those on jarring. Benzene hexachloride technical grade dust, which ranked second to chlordan spray in the jarring table, is in first place in the harvest data, averaging 7.5 times as efficient as lead arsenate. Differences between treatments at harvest are frequently masked by excessive early dropping of infested fruit; thinning; subsequent lead arsenate treatments given after final applications of organic insecticides; and by movements of beetles from outside the plots or from one plot to another, but it is felt that the large size of the plots partially offsets these factors.

The effect of the benzene hexachloride and chlordan on the oriental fruit moth is shown in part by the record of wormy drops given in table 3. These records were obtained by finding actual larvae in the fruit or by the characteristic frass. The markedly larger numbers of infested fruit in the chlordan and benzene hexachloride sprayed blocks, as seen in table 3, were observed both in the drops and in fruit on the tree, often up to the dividing line of the plots, indicating that it might have been due to something besides parasite reduction. Twig collections from benzene hexachloride and lead arsenate blocks, reared in the Federal Oriental Fruit Moth Parasite Laboratory in Moorestown, N. J., were thought by Dr. H. W. Allen to show very little differences in parasitism. The

Table 4.—Final infestation, plum curculio, 1948. Average per cent of wormy peaches with ratios of lead arsenate to other treatments.

Orchard	Lead Ars.	Chlordan								Benzene Hexachloride Spray						Benzene Hexachloride Dust			
		1 Lb. Every Time		1 Lb. Skip Time		0.5 Lb. Every Time		Dust 5%		Technical Every Time		Technical Skip Time		Refined		Technical		Refined	
		T.[1]	R.[2]	T.	R.	T.	R.	T.	R.	T.	R.	T.	R.	T.	R.	T.	R.	T.	R.
Baumann	3.5	0	3.5					4.5	.7	0	3.5			0	3.5	.5	7.0		
Broom	3.0							2.5	1.2							.7	4.3	0	3.0
Connel	13.8	3.7	3.7	10.0	1.3	4.0	3.4	7.5	1.8	3.0	4.6	2.5	5.5	5.0	2.5	0	13.8	6.0	2.3
Fred Heaton	2.0	0	2.0	.5	4.0					0	2.0	2.0	1.0						
Lindorf Heaton	1.0	1.0	1.0			3.0	.3			4.5	.2								
Sauer	12.5							15.0	.8							3.2	3.9	8.0	1.6
Average No.	5.9	1.2		5.2		4.0		7.3		1.9		2.2		2.5		1.3		5.7	
Average Ratios			4.3		1.5		2.1		1.1		2.7		3.5		3.5		7.5		2.1

[1] T. = Total.

[2] R. = Ratio of lead arsenate to other materials. Ratios computed only on pertinent lead averages.

Table 5.—Summary of taste tests from orchards in 1948, by food specialist. Most fruit received 6 to 9 applications. Harvest Aug. 1.

TREATMENT	NO. OF SAMPLES	NUMBER CLASSED AS MUSTY
Chlordan spray	6	0
Chlordan dust	4	0
Lead Arsenate, spray or dust	7	0
Benzene hexachloride (refined) spray	2	0
Benzene hexachloride (refined) dust	4	0
Benzene hexachlorude (technical) spray	9	3[1]
Benzene hexachloride (technical) dust	8	0

[1] Of the three classed as musty one received 6 benzene hexachloride sprays ending July 7, one received 9 sprays ending July 13, one received 4 sprays ending June 13.

Table 6.—Summary of taste tests made by National Canners Association from fruit in Connel orchard, 1948.

TREATMENT	AVERAGE RATING OF TASTERS[1]			
	Sprayed Fruit		Dusted Fruit	
	Sample 1	Sample 2	Sample 1	Sample 2
Lead Arsenate (control)	1.0	1.0	1.0	1.0
Benzene hexachloride, technical	2.6	2.4	1.5	2.4
Benzene hexachloride, refined	1.5	1.7	1.3	1.5
Chlordan	1.4	1.6	1.3	1.1

[1] Rating of "1" no off flavor, "2" trace of off flavor, "3" definite off flavor. All plots received seven applications ending 6 weeks before harvest. Eleven persons on panel for sprayed plots, nine for dusted plots.

fact that none of the blocks dusted with organic insecticides showed appreciably more Oriental fruit moth infestation than the lead arsenate blocks may be due to mechanical control by the oil dust itself. Up to 80 per cent control with oil dust containing no poison was proved over a period of years in Illinois experiments.

Taste tests, summarized in table 5, were made of both raw and cooked peaches ready for canning by a food specialist of Southern Illinois University, Mrs. E. D. Barnes. The 40 lots of fruit indicated in table 5 were from 38 treatments in the seven test orchards and from two orchards that received heavy benzene hexachloride spray and dust schedules. These taste tests indicate that only benzene hexachloride will produce a musty flavor. In 1947 taste tests it was shown that benzene hexachloride dust was much less likely to produce an off flavor than the spray, and the data for 1948 seem to substantiate this idea.

In addition to these tests samples from one orchard (Connel) in 1948 were canned by the American Can Co. of Chicago and tested in the National Canners' Association Research Laboratories, Washington, D. C. These are summarized in table 6. The lead arsenate treated peaches were offered as controls with which the other samples were compared. It will be seen that the technical benzene hexachloride rates highest in off flavor.

SUMMARY.—Large-scale tests with chlordan and benzene hexachloride and lead arsenate were conducted in six southern Illinois orchards in 1947 and in seven in 1948. Three methods of determining comparative efficiency were used. Jarring, collecting and examining drops, and making harvest infestation records. The most efficient treatments were chlordan as a spray, 1 lb. actual chlordan per 100 gallons; benzene hexachloride wettable powder, technical grade, 6 per cent gamma at 3 lbs. per 100 gallons: and a 1 per cent benzene hexachloride gamma dust, technical grade, all at 7 to 10 day intervals in six or seven applications. These treatments were from 3 to 10 times as efficient as lead arsenate for the control of plum curculio. Lengthening the intervals between sprays decreased the efficiency, especially with benzene hexachloride, as did reducing the dosage of chlordan from 1 lb. to 0.5 lb. Refined benzene hexachloride sprays and dusts with other than gamma isomers removed were less efficient than the technical grade. Chlordan dust at 5 per cent strength was quite inferior to the spray at 1 lb. actual chlordan in 100 gallons. Jarring data indicate that more of the value of benzene hexachloride lies in its ability to kill larvae in the drop fruit than to kill adults and that chlordan kills more of the overwintering adults than does benzene hexachloride, probably accounting for the fewer stings observed in the chlordan treated blocks. There was a decided increase in the infestation of Oriental Fruit Moth shown in drop peaches in benzene hexachloride and chlordan sprayed blocks as compared with lead arsenate. In taste tests conducted by a food specialist three of nine lots of raw and cooked peaches sprayed with technical grade benzene hexachloride had a musty flavor, but two of the three had been sprayed late into the second brood period. No off flavor was detected in any other treatment, including benzene hexachloride dust. Taste tests made by the National Canners' Association showed technical benzene hexachloride giving highest rating of off flavored fruit.

Effect of an Experimental Field Application of DDT Dust on *Nomia melanderi*[1]

GEORGE E. BOHART and F. V. LIEBERMAN,[2] *U.S.D.A., Agr. Res. Admin., Bureau of Entomology and Plant Quarantine*[3]

It has generally been assumed that populations of native wild bees react in much the same manner as honeybees to field applications of insecticides. For this reason and because the wild species are often uncommon and difficult to observe, few attempts have been made to determine how they are affected. The many species of wild bees differ widely among themselves and from honeybees biologically, particularly as to social behavior. Consequently, it is reasonable to predict that, although individual field bees of the various species might be similarly affected by insecticides, populations would not. The importance of wild bees in the pollination of wild and cultivated plants makes it desirable for us to determine the effect of commercial insecticidal applications on many of the genera.

The effect of a field application of DDT dust on *Nomia melanderi* Ckll. near Delta, Utah, is described in this paper.

Nomia melanderi is a highly efficient pollinator of alfalfa. When the nesting grounds are close to alfalfa, populations on the fields are often sufficient to set a good crop of seed quickly and without help from other bees. Although the females trip the alfalfa blossoms more rapidly and consistently than do the males, the latter are valuable under certain conditions.

Nomia bees nest in the ground in large aggregations. Adults are active in July and August in the Intermountain States, where two and possibly three generations are produced in a season. Larvae of the last brood overwinter in their cells as prepupae and pupate shortly before they emerge the following July. Females spend the night in their burrows, but sometimes the males "sleep out" on tall weeds, such as sedges and sweet clover. Each female constructs and provisions her own nest. Consequently, destruction of a field bee by DDT or other contact insecticides stops progress on her nest and leaves it unprotected from parasites and other destructive agents. This situation contrasts sharply with that in honeybee colonies, where destruction of field forces may cause a temporary deficit of field products in the hive, but hive bees remain to rear brood produced by the queen and the field force is gradually renewed.

REVIEW OF LITERATURE.—Published reports on the effect of insecticides on wild bees have been made in papers primarily concerned with honeybees. Consequently the data presented here are mainly of interest in comparison with corresponding data on honeybees.

Shaw (1946), in Massachusetts, caged honeybees, bumblebees, and solitary bees, and dusted them with DDT. In two tests honeybees and solitary bees succumbed within 24 hours, but bumble bees remained alive in the first test for 36 hours and in the second for 60 hours.

Way & Synge (1948) in laboratory and field tests in England studied the effects of DDT on honeybees and wild bees. When kept in cages and sprayed or dusted with DDT, bumblebee workers were about as susceptible as honeybee workers, whereas queens and drones were more resistant. *Andrena flavipes* Panz., when caged with blossoms sprayed or dusted with DDT, refused to remain on the flowers. In the field *Bombus pratorum* (L.), *Andrena* spp., and *Osmia rufa* (L.) as well as honeybees were apparently not affected by short periods of contact with DDT-treated blossoms.

Linsley & MacSwain (1947) in California, while studying the effects on honey bees of field applications of DDT dust to alfalfa, made some incidental observations on wild bees. The small populations of wild bees present were not depressed on the day of dusting as were the honeybee populations, and in one field bumble bees were more abundant than they had been on the previous day. A few specimens of *Nomia peninsularis* Ckll. collected from dusted alfalfa and held in cages were still alive after 24 hours, although honeybees in corresponding tests showed 15 to 100 per cent mortality in the same period.

[1] Hymenoptera, Apoidae, Halictidae.

[2] The assistance of Robert W. McAdams, Utah Agricultural Experiment Station, is gratefully acknowledged.

[3] In cooperation with the Utah Agricultural Experiment Station.

Table 1.—Effect of a field application of DDT dust on visitation to alfalfa by *Nomia melanderi*.

Date Counts Were Made	Bees Counted on Alfalfa Dusted With DDT		Bees Captured on Volunteer Sweet Clover			
			Within Dusted Acreage		Outside Dusted Acreage	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
			Before the Dusting			
July 14	—	46	—	—	—	—
16	—	62	—	—	—	5
25	—	92	—	30	—	7
29	120	—	—	—	—	—
30	348	141	—	54	—	17
			After the Dusting			
July 31	103	162	32	46	12	30
August 1	144	163	12	9	7	8
5	—	137[1]	—	17	—	0
6	71[1]	—	20	—	0	—

[1] Count based on only 200 square yards.

PROCEDURE.—Sixteen acres of alfalfa near Delta were chosen for the test. This was the only alfalfa within a radius of several miles. At the time of the test the alfalfa was in early full bloom, and it remained attractive to bees for a week.

A nesting site of *Nomia melanderi*, estimated to contain from 25 to 50 thousand nests, was situated about 25 yards from one corner of the field. This site and a much smaller one adjoining the same corner of the field were the only sites that could be found within reasonable flight range. The aggregation seemed to be at its peak of activity. Many males and a few females of a new brood emerged during the week after the dusting.

Dust was applied on July 31, 1948, between 6:30 and 7:30 A.M., before *Nomia* bees were on the alfalfa. Three per cent DDT in a 1-to-4 mixture of frianite and talc was applied by power equipment at approximately 20 pounds per acre.

During the week preceding the test and for a week thereafter, alfalfa, white sweet clover, and Russian thistle were the principal plants visited by *Nomia*. On July 25 pollen taken from the legs of *Nomia* at the nesting site was estimated to be 30 per cent alfalfa, 50 per cent sweet clover, and 11 per cent Russian thistle. From July 27 to 30 nearly all sweet clover within two miles, except that within the acreage to be treated, was mowed. As a consequence, on July 30 pollen brought to the nests was 59 per cent alfalfa, 19 per cent sweet clover, and 22 per cent Russian thistle. These collection data indicate that 59 per cent of the female *Nomia* were exposed to the treatment. However, since most of the uncut sweet clover and the best blooming Russian thistle were in the dusted acreage, it is probable that even more of the bees were exposed.

The days were clear and warm throughout the period of observation, although strong winds blew for short periods on some afternoons. On the morning of the treatment dew was light and there was little wind.

Methods of measurement.—The methods used for measuring repellent and toxic effects of the dust were refined from those used in a similar test in 1947. During the 1947 experiment undeveloped techniques, in addition to poor weather, weak alfalfa bloom, and abundant untreated sweet clover, confused the results. The following measurements were employed in 1948:

1. Bees were observed on a total area of 400 square yards in the alfalfa field. Counts were made at approximately 10 A.M. and 2 P.M. Fifty counts, each including bees observed in 4 square yards, were made in each of two portions of the field (Table 1). The method of counting is described by Vansell & Todd (1946).

2. Bees were swept in 50 net strokes over sweet clover. Five sweepings, each consisting of 10 strokes, were made at the times indicated in table 1. The sweeping was done with rapid, full-arm strokes, as described by Linsley (1946). Corresponding sweeps were made in the dusted area and in a small patch left undusted.

3. Pollen was removed from the legs of bees at the nesting site and the proportions of the various species of pollen collected were determined (Table 2).

Table 2.—Effect of a field application of DDT dust on selection of pollen by *Nomia melanderi*.

Date of Counts	Number of Pollen Loads Examined	Per Cent of Pollen by Sources[1]			
		Alfalfa	Sweet Clover	Russian Thistle	All Others
		Before the Dusting			
July 25	11	30	59	11	Trace
29	18	54	42	4	0
30	21	59	19	22	Trace
		After the Dusting			
July 31	25	41	27	31	1
August 8	10	75	20	5	Trace
6	18	87	6	7	Trace

[1] Loads were taken from bees returning to their nests. When they were mixed as to source, the percentage of each species of pollen was estimated.

4. Bees were taken in 75 net strokes over the nesting site. Five sweepings, each consisting of five strokes, were made over each of three sections of the nesting site at 4 P.M. (Table 3).

5. The number of active nests was ascertained. Nest entrances in eight designates areas, totaling approximately 30 square yards, were counted at 6:30 A.M. before the bees left their nests (Table 3). These open entrances were closed at the time they were counted. The first five areas chosen were covered with fresh sand and then raked over to obliterate the entrances. Since this method appeared to cause a decline in the number of active nests, three more areas were established in which the landmarks were left undisturbed except for the nest entrances themselves, which were pinched shut each morning. The counts represent the number of active nests of the preceding day, which in turn represent the number of female bees surviving one day earlier. For example, females surviving the dusting and other hazards on July 31 forced open on August 1 the nests which we counted and then closed again before bee flight on August 2.

6. Dead bees at the nesting site were examined and counted. Dead bees within the eight areas were picked up and checked early in the morning for possible parasitism (Table 3).

RESULTS.—*Repellency:* As with honeybees, the number of adult *Nomia* bees visiting a field recently dusted with DDT is more likely a measure of the repellency of the dust than of its toxicity. This is especially true when a drastic reduction in field population is accompanied by evidence of relatively light mortality at the nesting site. Increase in population on undusted bloom furnishes additional evidence of repellency.

There were about three times as many *Nomia* bees on the alfalfa on the morning before the dusting as on the next morning (Table 1). However, the former population appears to have been exceptionally large, and its contrast with the population after the dusting presents an exaggerated picture. Compared with populations measured on other days, if this one day's exceptionally large count is ignored, the population immediately following the dusting appears to have been only slightly depressed. By afternoon the counts had returned to normal.

On the day of the test there was also a slight depression in the counts on sweet clover within the dusted area, and this

Table 3.—Effect of a field application of DDT dust on *Nomia melanderi* at the nesting site.

Date Counts Were Made	Number of Dead Bees at Nesting Site	Number of Active Nests in Areas				Number of Bees Captured Over Nesting Site
		1 to 3	4 to 5	6 to 8	All	
		Before the Dusting				
July 14	—	308	—	—	—	—
23	—	289	741	—	—	—
24	0	248	693	—	—	52
25	—	—	—	—	—	—
27	—	284	701	—	—	—
28	1[1]	277	705	931	1913	—
29	0	208	698	915	1821	—
30	0	178	680	858	1716	46
		After the Dusting				
July 31	30[2]	130	482	746	1358	54
August 1	—	—	—	—	—	37
4	0	131	456	732	1319	—
5	2[1]	—	—	—	—	48
6	—	—	—	—	—	56

[1] Parasitized.
[2] None parasitized; also found were two *Halictus ligatus* and one *Nomia nevadensis*.

depression became more pronounced on the next day. A week later the counts had returned to a figure in line with the advanced maturity of the sweet clover. The number of *Nomia* bees swept over undusted sweet clover was twice as great on the afternoon of the test as on the previous afternoon representing a temporary reversal of the declining trend of visitations coincident with the rapidly maturing plants.

In 1947 the population on alfalfa on the day of dusting was much more depressed than in 1948. However, the period of depression was equally short. More undusted sweet clover, serving as an alternate host, may have been responsible.

Evidence of repellency in the 1948 test is bolstered by data on the percentages of pollen collected from various sources (Table 2). It is apparent that both the upward trend of pollen collection from alfalfa and the downward trend from sweet clover were reversed after the dusting. Russian thistle showed a strong increase in the samples taken on the day of dusting. Since at least some of the blooming sweet clover and Russian thistle were in undusted territory, a rather convincing picture of moderate displacement of *Nomia* from dusted to undusted plants is presented.

Toxicity.—The most direct evidence of mortality to *Nomia* is furnished by the 30 dead bees collected at the nesting site on July 31 (Table 3). This number is slightly more than 2 per cent of all the active nests in the sample areas. Of course this figure does not take into account the bees that may have died away from their nesting area or in their nests.

Activity of bees over the nesting site remained relatively constant during the period of observation, although the least number of bees was swept on the day after the dusting. On this day males, which seem to be erratic in behavior, were scarce in the sweepings.

Although our eight sample areas indicated a rather constant decline in nesting activity during the period of observation, five of them showed the most precipitous drop on July 31. From July 28 to 30 the total number of active nests in all areas declined by about 100 each day; on July 31 the decline was 358, after which date there was little decline for at least 4 days. When the daily reduction from July 28 to 30 is subtracted from the reduction on July 31, it is estimated that approximately 250 nests, or 15 per cent, were rendered inactive by the dusting. We recognize that the evidence for 15 per cent mortality is circumstantial, as it deals with undetermined and uncontrolled factors of nest disturbance and life-cycle rhythms. It does not seem out of line, however, with the direct evidence of mortality furnished by the conspicuous appearance of dead bees at the nest entrances after the dusting.

In this experiment the dust was applied before the bees were on the field, and the dosage was light. That mortality resulted indicates that DDT should be used with caution on areas where *Nomia* bees may nest or forage.

SUMMARY.—Three-per cent DDT dust at 20 pounds per acre was applied in the early morning to 16 acres of alfalfa in bloom near Delta, Utah, in order to test the effect of the insecticide on a population of *Nomia* bees. It was ascertained that more than 50 per cent of the female bees in the nesting site studied visited the alfalfa on the day it was dusted.

The evidence indicated that the application was moderately repellent to the bees for a few hours. More than 2 per cent of the females nesting in sample areas were found dead at their nest entrances after the dusting, and about 15 per cent of the nests in the same areas became inactive, apparently as a result of the treatment.

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Comparative Toxicity of Various Insecticides to the Honeybee

E. Häfliger[1]

The introduction of insecticides for the protection of crops is accompanied by a latent danger for honeybees. The beekeeper is not in a position to object, since the use of insecticides is a necessity in modern agriculture. On the other hand, the farmer, especially the fruit-grower, has also considerable interest in not destroying the bees, as they are necessary agents in pollination. Thus the primary problem is to make this interdependence clear and to recommend precautionary measures for the avoidance of large scale damage.

The ideal insecticide would be one which would be selectively non-toxic to honeybees. Since it will hardly be possible to develop a product complying 100 per cent with this ideal requirement, the most favourable compromise must be sought. For this, it is necessary to make a *comparative* investigation of the *relative* toxicity of various insecticides to honeybees.

As the results of such research are absolutely dependent on the technique used, the choice of the latter is very important. This is well illustrated by the controversy regarding DDT-insecticides, which some workers find to be harmless to bees whereas others have found them highly toxic.

Conclusions applicable to practice can be drawn from laboratory tests only in so far as the latter truly represent field conditions. As honeybees are highly organized social insects, there are considerable difficulties in carrying out laboratory tests with them. One of the most striking factors in the life of the honeybee colony is the heat evolved, which is connected with the social life of the insect. The author has already been able to demonstrate that the high biological temperature of bees gives them a considerable resistance to the action of DDT-preparations (Häfliger 1948).

Influence of Temperature on the Toxicity of Various Insecticides as Stomach Poison for Bees.—The existence of the phenomenon of thermoresistance was confirmed by purely qualitative contact experiments. To determine the quantitative relationship between temperature and toxicity, it was decided to use the separate feeding method.

The bees used were taken in July and August from the last honeycomb of each hive. Before commencing the trials, they were kept in a cage for 24 hours without food.

Table 1.—Insecticides used in tests.

Active Ingredient	Physical Nature of Composition
1. DDT	50% wettable powder
2. Calcium arsenate	wettable powder
3. Benzene hexachloride 10% gamma isomer	wettable powder
4. Parathion	emulsion

The insecticides were diluted with 50 per cent sugar solution to the concentrations given in table 2.

Administration of the Poisoned Food.—The bees were fed separately with a micro-pipette. Each bee received 10 cubic milimeters. Each experimental series comprised 10 bees. The pipette was frequently rotated and inverted during feeding in order to prevent, as far as possible, the settling out of the suspensoid.

Experimental Conditions.—After feeding, the bees were put in series of 10 into small test cages kept in thermostats at the following temperatures: 20, 28 and 36° C. The relative humidity was 60 to 80 per cent. In the cages the bees had an unlimited quantity of 50 per cent sugar solution available as food.

Data Recorded.—The number of dead bees in the cages was noted daily. Table 2 shows the mortality figures after 1 to 4 days as a function of temperature and concentration (for the 4 insecticides investigated).

Results.—For concentrations which after 2 to 4 days were grouped on either side of 50 per cent mortality, a fresh series of experiments were carried out, and the mean lethal dose (LD-50) calculated from the arithmetical mean (using logarithmic probit graph paper). In figure 1, the lethal dose LD-50 is given as a function of the temperature.

[1] J. R. Geigy, S.A., Basle, Switzerland.

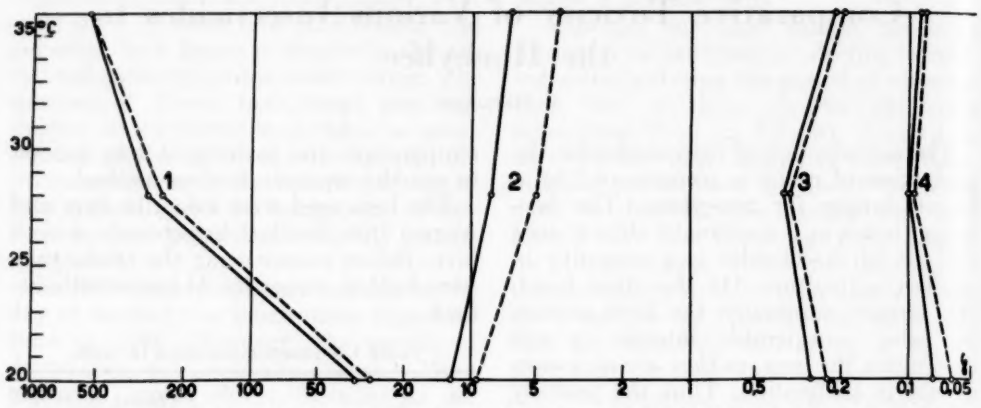

FIG. 1.—Average lethal dose in γ/bee as function of the temperature in °C. (1γ = 1 microgram = one millionth part of a gram)
1. DDT
2. Calcium arsenate
3. γ isomer of benzene hexachloride
4. Parathion
——— calculated after 2 days.
- - - - - calculated after 4 days.

DISCUSSION OF THE RESULTS.—The toxicity of the insecticides tested towards bees varies in the following points (Fig. 1.) influence of temperature, order of size of lethal dose LD-50 and the rapidity of poisoning.

Dichlorodiphenyltrichlorethane: The LD-50 of a DDT-wettable powder depends in large measure on the temperature. The resistance of the bees to DDT-insecticides grows with rising temperature within the range of temperatures tested (20° to 36° C.). The LD-50 increases from 32γ to 560γ, i.e. 18 times. The influence of temperature on the toxicity of DDT-products when employed as a contact insecticide which is already known, also applies therefore when they act as a stomach poison, and in this case, the relationship has been established quantitatively. This effect must be considered as being of considerable practical importance, as bees usually live in the upper part of the temperature range examined. From February to September, the hive temperature is fairly constant between 34 and 36° C. The biological optimum temperature probably lies between 28 and 30° C. Individual bees which are exposed to a lower external temperature (female workers gathering pollen) can develop a body temperature through muscular work which is considerably above that of their surroundings. Himmer (1925) found that the average difference between body and surrounding temperature lies around12.4° C. It is therefore understandable that DDT-insecticides have proved to be much less toxic in agricultural use than certain laboratory tests at 20° C. have indicated.

Calcium arsenate: Calcium arsenate seems to be more toxic at higher temperatures. As opposed to the other insecticides tested, its poisonous action on bees develops very slowly. The other insecticides tested reach maximum toxicity after 1 or 2 days, whereas for calcium arsenate more than half the bees died between the second and the fourth day.

Benzene hexachloride: The toxic effect shows no specially outstanding dependence on temperature. The small bend in the curve occurring at 28° can be interpreted according to Gosswald's (1934), hypothesis *i.e.* that resistance is generally at a maximum when the optimal biological temperature is present. When compared with DDT-suspension, benzene hexachloride proves to be 100 to 250 times more toxic in the normal biological temperature range.

Parathion: The course of poisoning and the influence of temperature are the same as with benzene hexachloride. Only the order of the LD-50 varies. Parathion is approximately 3 times more toxic than the pure γ-isomer of benzene hexachloride

THE INFLUNECE OF THE PHYSICAL PROPERTIES OF INSECTICIDES ON THEIR TOXICITY.—It is well known that the particle-size and shape and thereby the

Table 2.—Influence of temperature on the toxicity of insecticides. The groups of numbers indicate the number of dead bees after 1 to 4 days.

		DDT			Calcium Arsenate		
γ/Bee	Dilution	20° C.	28° C.	36° C.	20° C.	28° C.	36° C.
1000	1: 10			10			
500	1: 20		10 8/9/9/10	0/1/1/1 3/5/5/5			
200	1: 50		0/0/0/0 2/2/2/2	0/0/0/0 0/0/0/0			
100	1: 100	6/8/9/9	0/0/0/0				
50	1: 200	8/8/8/8 1/6/9/9	0/0/0/0				
20	1: 500	1/1/1/1 2/4/4/4			9/9/9/9 4/4/5/8	8/8/9/9 4/7/7/7	
10	1: 1,000				3/4/4/4 3/5/6/6	4/5/6/6 7/8/8/8	7/10 1/4/5/6
5	1: 2,000				1/1/1/1 2/2/2/2	1/1/3/6 4/5/5/7	2/4/5/6 3/4/6/9
2	1: 5,000					0/0/0/1 0/0/0/1	0/0/0/0 0/0/0/1
		γ-Benzene Hexachloride			Parathion		
1	1: 10,000						
0·5	1: 20,000	9/9/10 8/8/8/9	10 6/6/6/7	10			
0·2	1: 50,000	6/6/7/8 1/1/1/1	1/1/1/1 0/0/0/0	3/4/5/5 3/3/3/5	10 9/10	10 10	10
0·1	1: 100,000	0/0/0/0	1/1/1/1	1/1/3/– 0/0/0/0	7/9/10 7/7/7/8	9/10 0/0/0/0	8/8/9/9 4/4/4/4
0·05	1: 200,000	0/0/–	0/0/–	1/1/–/–	1/1/4/5 0/0/1/3	5/5/5/5 0/0/1/1	1/1/1/1 1/1/1/1
0·02	1: 500,000				0/0/0/0	0/0/0/0	0/0/0/0
0·01	1:1,000,000				0/0/0/0	1/1/1/1	0/0/0/0

internal surface area, solubility, etc. can considerably influence the toxicity of insecticides, Therefore, when it is desired to apply conclusions derived from laboratory tests to large scale applications, these tests should be carried out with the commercial insecticides used in practice. However, "home-made" insecticides are still often used for laboratory work and these products can be quite different from commercial insecticides in physical properties. In the laboratory, suspensions prepared from wettable powders are seldom used because of their swift sedimentation. To determine the influence of the above mentioned physical factors on the toxicity, tests were carried out with the following DDT preparations:

(a) Commercial product, DDT 50,[1] wettable powder in suspension (see test A)

(b) Experimental preparation consisting of a suspension of finely ground wettable powder composed of almost isodiametric particles with a particle-size of 1 t μ.

(c) Very fine DDT crystalline needles of a length of 1 to 2 μ ("pseudocolloidal"), precipitated from alcohol in aqueous sugar solution.

(d) Emulsion prepared from a commercial 20 per cent emulsifiable solution. These products were fed to bees in the same way as described under A. The results are collected in table 3 and evaluated graphically in figure 2.

[1] *Qesarol.*

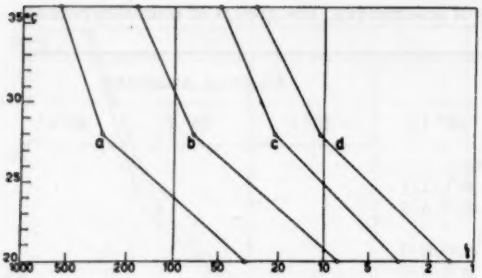

FIG. 2.—Influence of physical characteristics and temperature on the toxicity of DDT products to bees. Abscissae: LD-50 in γ/bee. Ordinates: Temperatures in °C. *a*—*d*: See explanation in text above.

DISCUSSION OF RESULTS.—The toxicity increases with decreasing particle size and consequently with increasing solubility (a–c). The emulsion (d) which contains the active ingredient in dissolved form is about 20 times more toxic than the suspension of 50 per cent wettable powder (a). The highly dispersed, microcrystalline system (c) has a toxic effect nearer to that of the emulsion than to that of the suspension (a). The influence of temperature is approximately the same for all 4 preparations.

Combination of the factors of temperature and particle size or solubility yields (within the limits of the experiments) absolute values for LD-50 which lie between the lower limit of 1.5γ 20 per cent emulsion 20° C.) and the upper limit of 560γ (50 per cent wettable powder 36° C.).

This shows very clearly that any experimental value, such as LD-50, without reference to the conditions under which it was determined can give no definite information and consequently does not permit of any practical conclusions being drawn.

THE "DANGER INDEX" FOR BEES.—The absolute toxicity expressed in the LD-50 is of course important for the determination of the danger associated with an insecticide in practice. However, the extent of exposure, *i.e.* dosage and concentration in practical use, is certainly just as important. It is therefore necessary to compare the extent of exposure with

Table 3. Influence of particle size on toxicity.

		DDT								
		Fine Milled wettable powder, 1–2μ			Suspension, small crystalline needles			Emulsion		
γ/BEE	DILUTION	20° C.	28° C.	36° C.	20° C.	28° C.	36° C.	20° C.	28° C.	36° C.
500	1: 20			10 9/9						
200	1: 50		10	9/9 6/6 4/5						
100	1: 100		8/8 6/6	1/1 0/0			•			10
550	1: 200		4/4 1/1			10 10	8/8 5/5 2/2			10 9/9
20	1: 500	10 9/9	1			7/7 1/1	0/0 0/0			2/2 1/1
10	1: 1'000	9/9 4/4				1/1 0/0			8/8 1/1	0/0
5	1: 2'000	3/3 2/2			10 3/3				1/1 0/0	
2	1: 5'000				3/5 1/2			10 5/5		
1	1:10'000				0/2 1/1			0/4 0/0		

the absolute toxicity (LD-50). for this purpose, we introduce the

$$\text{Index } I = \frac{\text{concentration applied in per cent}}{\text{toxic concentration for bees in per cent}} = \frac{C_a}{C_t}.$$

C_t is defined as that concentration which contains the LD-50 in 10 cubic millimeters. C_a represents the concentration of the insecticide applied in agriculture, which is a good measure of the extent of exposure. The index can, accordingly, be calculated only for those preparations which are used in practice (Table 4).

Table 3.—Calculation of the "danger index."

Product	Conc. Used in Practice Per Cent	LD-50		I	
		28° C.	36° C.	28	36
DDT					
wettable powder	0.1	300	560	0.03	0.02
emulsion	0.05	10	30	0.5	0.02
Benzene hexachloride					
wettable powder	0.01	0.37	0.2	3	5
Parathion					
emulsion	0.01	0.1	0.09	10	11
Calcium arsenate					
wettable powder	0.4	5	4	8	10

Substantially more reliable deductions can be made from these indices regarding the practical danger than from the LD-50. The larger the index, the greater the danger of poisoning. Calcium arsenate, which is recognized as being one of the most dangerous insecticides, has an index I=8–10. We must therefore also class parathion, which has a similar index (I=10–11), as being very dangerous, so long as we rely only on laboratory tests as our sole source of information, and there is no practical evidence to the contrary. Benzene hexachloride is somewhat better than calcium arsenate, with an index of I=3–5, although not widely removed from it. Though still relatively meager, there is nevertheless definite practical evidence that benzene hexachloride preparations can be extremely dangerous to bees when used in agriculture.

DDT preparations, particularly the wettable powder, have a most favorable index (I=0.02−0.03). The index of the emulsion is also less than 1. This is corroborated by practical experience. Whereas arsenates alone are responsible for the poisoning of over 1000 bee-colonies every year in the U.S.A. according to Eckert (1948), no case has been reported where the use of DDT-products has resulted in such poisoning in spite of its intensive use in agriculture all over the world.

Calculation of the index is based on the two most important factors governing danger under practical conditions, viz. LD-50 and exposure. In practice, other factors can also play a part. Thus, the danger can be diminished by the use of insecticides having a simultaneous repellent action (nicotine), or which rapidly decompose (rotenone, pyrethrum). The danger is augmented by the following factors: high vapor pressure (benzene hexachloride, parathion), cumulative action (arsenates), long persisting action.

These are to some extent factors of a secondary nature which partly neutralize one another. Example: vaporizing properties which augment the danger are linked with a short duration of action which diminishes it. A final judgement of the practical danger can therefore only be based on evidence derived from practice. The index is however useful for a preliminary evaluation of new insecticides.

SUMMARY.—The LD-50 of the following insecticides has been determined for bees in feeding tests:[1] Special attention has been paid to the influence of temperature and the particle size of the preparations. The absolute toxicity expressed as LD-50 has been combined with the insecticide concentration applied as a measure of the degree of exposure. This has led to the introduction of a "danger index."

The toxicity of DDT compounds towards bees is strongly dependent upon temperature. In the biological temperature range, bees can survive exposure to 10 to 20 times more of this compound than at the usual laboratory temperature. This explains why bees can be poisoned with very small amounts in the laboratory while not a single case in a bee colony being poisoned has occurred in the agricultural use of DDT insecticides. Judging from the experiments described, benzene hexachloride appears to be about 200 times, and parathion (like calcium arsenate) as much as 300 to 500 times more toxic to bees than DDT-suspensions.

[1] Four different DDT-formulations, benzene hexachloride parathion and calcium arsenate.

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Relative Humidity and Temperature Within the Beehive

E. OERTEL, *U.S.D.A., Agri. Res. Adm., Bureau of Entomology and Plant Quarantine, Baton Rouge, Louisiana*[1]

Little is known of the relative humidity within the beehive, although it is supposed to be closely associated with the ripening of honey. At Baton Rouge, La., honey commonly ferments in the comb while on the hive in the summertime. Jessup[2] studied the problem of relative humidity by using a hygrothermograph above the top extracting super of a beehive at Ames, Iowa, in the summer of 1923. E. F. Phillips and Geo. Demuth obtained some relative humidity records (unpublished) from within the winter cluster of a colony of bees.

Much work has been done to determine the temperature within the hive during the winter (Milum 1929, 1944), but little on hive temperatures in the summer. Milum found that temperatures in the brood nest ranged from 76.3° to 97.5° F., but in warm weather usually from 90° to 95°. Dunham (1931a) gave some of the temperatures within the brood nest of a colony in Ohio during August. He found that when the experimental heat chamber was at 93.5° the average temperature of the central brood area was 95.6° for a colony in a single-story hive. Dunham (1931b) found that the average hourly temperature in the central brood area ranged from 92.6° to 94.1°, in the outer brood area from 86.7° to 93°, and in the broodless area from 81.7° to 91.5°. This too was a colony in a single-story hive. The temperature of the room in which the hive was kept ranged from 78° to 88°. A chart by Dunham (1931c) shows that, when a single-story colony was subjected to external temperatures of about 53° in August, the central brood area maintained a temperature of about 93° and the outer brood area had a temperature of about 78°.

Some information obtained about the relative humidity and temperature within the beehive during the summertime at Baton Rouge will be presented here.

METHOD OF OBTAINING DATA.—Relative humidity and temperature within two beehives (colonies 3 and 51) at Baton Rouge were determined by the use of a recording hygrothermograph. The instrument was enclosed in a screen-wire cage to prevent bees from gnawing the hairs that make up one of the registering elements. The cage took up the space required by five standard combs; consequently only five combs remained in whichever hive body contained the instrument. Records were obtained below the brood chamber, within the brood chamber, within partly filled and filled honey supers, and above the supers. The prevailing relative humidity and temperature were recorded automatically on calibrated charts that hold a week's record. Data for the first 24 hours of each week have not been used, because the colony's activities were disrupted when the record sheets were changed. The hygrograph pen was set periodically according to the manufacturer's directions. Nevertheless, it occasionally was slightly out of adjustment.

Prevailing out-of-doors relative humidity and temperature were obtained from a recording hygrothermograph[3] within a

[1] In cooperation with Louisiana State University.
[2] Unpublished thesis, Iowa State College.
[3] Records were taken by the Division of Truck Crop and Garden Insect Investigations of this Bureau.

Table 1.—Average temperatures and relative humidities in a beehive (colony 51) for 6-day periods, Baton Rouge, La., 1947.

Date	Part of Hive	Temperature (°F.)				Relative Humidity (Per Cent)			
		6 a.m.	Noon	6 p.m.	12 p.m.	6 a.m.	Noon	6 p.m.	12 p.m.
May 6–11	Second brood chamber	94	95	96	96	45	46	44	46
May 13–18	Second honey chamber	82	96	92	84	52	44	42	48
June 24–29	Second brood chamber	92	94	95	93	58	57	56	57
July 8–13	Second honey super	84	90	91	86	59	49	44	51
Aug. 5–10	Second brood chamber	90	95	95	91	57	55	54	58
Aug. 12–17	First honey super	83	93	94	89	57	60	56	57
Aug. 19–24	Second honey super	81	88	89	83	69	65	61	66
Oct. 14–19	Second honey super	75	82	86	78	58	57	44	55

U. S. Weather Bureau shelter. The accuracy of the instrument used in the hive was not compared with that of the one used in the shelter. Colony 3 was slightly less than a half mile from the shelter, and colony 51 was slightly less than 4 miles away. Colony 51 was rated as a strong colony. Colony 3 was rated as weak in June and slightly below average in September and October. It is possible that weather conditions at the shelter were different from those surrounding the colonies.

RESULTS.—The extremes of relative humidity and temperature in the beehive, as recorded by the hygrothermograph, may be a little misleading, but when the figures for 6-day periods are averaged they show that the two factors tend to be fairly uniform (Table 1). Since there was only one comb of brood in the first brood chamber of colony 3, the conditions were not typical of a brood chamber containing several combs of brood. When the hygrothermograph was placed in the first brood chamber on September 22, a comb of young brood was placed on each side of the screen cage. When the instrument was removed, September 29, there was brood in only one of the two combs. The rest of the brood in the hive was in the second brood chamber.

During the season the temperatures in the second brood chamber for colony 51 ranged from 88° to 102° F., and for colony 3 from 80° to 96°. It is not known whether the brood temperatures reached these maxima. The temperature in the first honey super ranged from 78° to 100°, in the second honey super from 73° to 106°, and in the empty hive body above the second super from 68° to 106°.

The relative humidity in the second brood chamber (both colonies) ranged from 40 to 62 per cent, in the first honey super from 42 to 60 per cent, in the second honey super from 32 to 78 per cent, and in the empty hive body above the super from 36 to 90 per cent. Some of the records are shown in figure 1.

DISCUSSION.—The results obtained in the bottom brood chamber of colony 3 will not be considered in this discussion, for it is believed that the single comb of brood does not represent a typical brood chamber. The extreme temperatures recorded in the second brood chamber are greater than those in the brood nest as given by Milum (1929) and by Dunham (1931b). Dunham gives temperature averages, not the extremes. Differences can be expected, considering that these two men used thermocouples between combs of brood, whereas the hygrothermograph recorded the temperature for the space normally occupied by five combs. Moreover, the sun shining against the sides and

Table 2.—Amount of moisture in the air at certain temperatures and relative humidities.[1]

Temperature (°F.)	Relative Humidity (Per Cent)	Water Vapor (Grains per Cubic Foot)
100	50	9.883
95	50	8.562
90	90	13.311
	80	11.832
	60	8.874
	40	5.916
80	90	9.841
	50	5.467
70	90	7.182
	50	3.990
60	90	5.170
	50	2.872

[1] Marvin, C. F. Psychrometric tables for obtaining the vapor pressure, relative humidity, and temperature of the dew-point. U. S. Dept. Agr., Weather Bur., 87 pp. 1915.

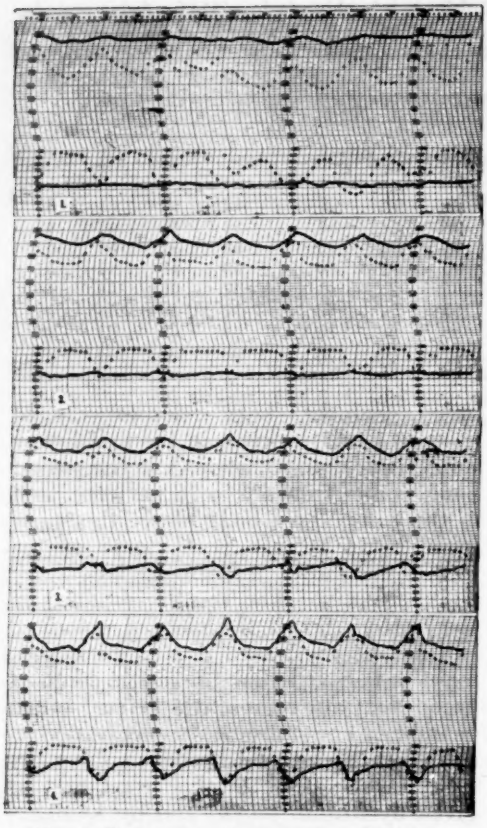

FIG. 1. POSITION OF INSTRUMENTS IN TESTS.

1. In second brood chamber, Colony, 3, May 5 to 12, 1947. Above: Solid line, temperature in hive; Broken line, temperature in shelter. Below: Solid line, relative humidity in hive; Broken line, relative humidity in shelter.
2. In first honey super above brood chamber. Colony 51, August 11 to 18, 1947. Above: Solid line, temperature in hive; Broken line, temperature in shelter. Below: Solid line, relative humidity in hive; Broken line, relative humidity in shelter.
3. In second honey super. Colony 51, August 18 to 25, 1947. Above: Solid line, temperature in hive; Broken line, temperature in shelter. Below: Solid line, relative humidity in hive; Solid line, relative humidity in shelter.
4. In empty hive body above second honey super. Colony 51, August 25 to September 1, 1947. Above: Solid line, temperature in hive; Broken line, temperature in shelter. Below: Solid line, relative humidity in hive; Broken line, relative humidity in shelter.

the top of the hive at Baton Rouge probably raised the temperature within the hive. By means of thermometers Jessup found temperatures ranging from 90° to 97° F. in the brood chamber and from 90° to 103° in the two supers.

Temperatures in the first honey super (just above the brood chambers) were much like those in the second brood chamber. Temperatures in the second honey super showed greater range—73° to 106° F. The temperatures in the empty hive body above the second honey super showed even greater range—68° to 106°. These results indicate that the greater the distance from the brood nest the greater was the range in temperature. They seem to confirm Dunham's statement (1931c) that "the temperature in the broodless area drifts (the extent depending on the strength and the condition of the colony) with the rise or fall of external temperatures."

The recorded humidity within the brood chamber and the first super ranged from 40 to 62 per cent. The relative humidity in the second honey super ranged from 32 to 78 per cent and in the empty hive body above the super from 36 to 90 per cent. The relative humidity within the hive (outside the brood nest) tended to vary with that outside. Since temperature governs the prevailing relative humidity, we would expect this variation, for the temperature range was greatest in the super farthest from the brood chamber.

Moisture is removed from nectar when it is being changed to honey. Probably more work is done by the bees in ripening honey in a humid region, such as Louisiana and nearby states,[1] than in more arid regions. According to the Atlas of American Agriculture (1936) the average daily temperatures in Louisiana ranged from 50° to 80° F. in April, 60° to 90° in May, and 70° to 90° in June, July, and August. The average relative humidity at 8 A.M. was 80 to 85 per cent in April and 85 per cent in July; at 2 P.M. 55 to 60 per cent in both these months; and at 8 P.M. 60 to 75 per cent in April and 65 to 75 per cent in July. At Baton Rouge a moisture content of 7.15 to 10.5 grains per cubic foot of air can be expected in July and August, and from 4.5 to 6.5 grains in April during the middle part of the day. Table 2 gives the amount of moisture in the air at certain temperatures and relative humidities.

From the data in tables 1 and 2 the experimental hives must have contained from 3 to 12 grains of water vapor per

[1] The U. S. Department of Agriculture (1941, p. 664) lists as the "Wettest State, Louisiana, with an annual average rainfall of 55.11 inches."

cubic foot of air, the amount depending upon prevailing conditions. Perhaps the high moisture content of some southern honeys (from 18 to 22 per cent at Baton Rouge) is caused by the frequent high relative humdities within hives. Lothrop (1937) showed that, at 68° F. and 60 per cent relative humidity, honeys containing 20 per cent of moisture neither lost nor gained moisture. At the same temperature but at lower humidities the honeys lost moisture and at higher humidities they gained moisture. At 70° and 60 per cent relative humidity the water content of air is calculated to be 4.788 grains per cubic foot. From his laboratory work Lothrop concluded that in the area bordering the Gulf of Mexico stored honey would tend to absorb moisture in the summer. Martin (1939) states, "Liquid honey of 17.4 per cent water content is in equilibrium with the water vapor in an atmosphere of 58 per cent relative humidity . . . ." At 58 per cent and 68° F. a cubic foot of air contains 4.33 grains of water vapor. (by interpolation, see footnote 1, table 2.). Reinhardt (1939) noted that, when the moisture content of the outside air fluctuated between 7.8 and 9.0 grains per cubic foot of air, the sugar concentration of the honey in an experimental comb decreased from about 79 per cent to 76 per cent. From these results it seems possible for honey to absorb moisture from the air under conditions that exist in beehives at Baton Rouge. Perhaps additional experimental work will show how the moisture content of honey in the combs in the hive in the South can be reduced.

Occasionally a queen rearer wishes to keep sealed queen cells in a constant-temperature cabinet for a few days. We recommend that the relative humidity within the cabinet be from 50 to 60 per cent and the temperature 93° F., to correspond to conditions within the brood nest of a bee colony.

SUMMARY.—Relative humidity and temperature in two beehives at Baton Rouge, La., were determined by the use of a recording hygrothermograph. Both factors were fairly uniform in the brood chamber, but were less uniform in the two honey supers. In other parts of the hive they tended to vary with the relative temperature and humidity outside.

At mid day in July and August at Baton Rouge from 7.15 to 10.5 grains of moisture per cubic foot of air may be expected within the beehive. The high moisture content of honey at Baton Rouge (18 to 22 per cent) may be the result of this high water content of the air within the hive. Queen cells in a cabinet should be kept at a relative humidity of 50 to 60 per cent.

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Toxicity to House Flies of Synthetic Compounds of the Pyrethrin Type in Relation to Chemical Structure

W. A. GERSDORFF, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

In their investigations of the constituents of pyrethrum flowers, LaForge & Barthel (1945) have demonstrated the existence of, in addition to pyrethrins I and II, two closely related compounds subsequently designated cinerins I and II. LaForge & Soloway (1947) have since revised the formula of the keto-alcoholic component by allocating the position of the hydroxyl group to position 4 instead of position 5 as heretofore accepted.

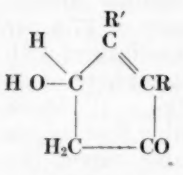
Owing to their somewhat simpler structure, the cinerins would be less difficult to prepare synthetically than the pyrethrins. LaForge & Barthel (1947) have found the cinerins to be more stable than the pyrethrins, and the author (Gersdorff 1947) has shown the corresponding esters to possess about the same order of toxicity when applied in space sprays to house flies. Therefore, efforts have been directed to the synthesis of cinerin I, the chrysanthemum monocarboxylic acid ester of 2-(2-butenyl)-4-hydroxy-3-methyl-2-cyclopenten-1-one.

Recently an isomer has been synthesized, but this compound was found to have considerably lower toxicity (LaForge *et al.* 1948). It differed chemically from cinerin I in two respects. Esterification was effected on the hydroxyl group in position 5 of the nucleus of the keto-alcoholic component, and the side chain of this component was probably a geometric form of that of cinerolone.

Schechter *et al.* (1949) have now devised a method for the synthesis of cyclopentenolones analogous to cinerolone, differing from it by the nature of the substituent groups in the nuclear 2 and 3 positions. These compounds, when esterified with chrysanthemum monocarboxylic acid, furnish esters analogous to cinerin I. A number of these esters have been prepared.

Since differences in configuration or optical activity may affect toxicity, the question of the relative toxicity of these synthetic compounds as compared with the natural pyrethrins and cinerins at once arises. It has already been shown (Gersdorff 1947) that toxicity is independent of the presence of optical activity in the keto-alcoholic component of both types of pyrethrins and cinerins. The question of the effect on toxicity of the chemical changes in the substituent groups is also of interest. Consideration of these questions has motivated the present investigation.

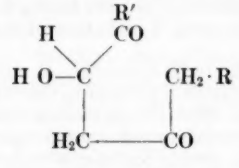
MATERIALS.—Seven substituted cyclopentenolones were prepared. They are represented by the general formula I, in which R indicates different side chains.



Formula I

Compound	*R*
a	$\cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CH_3$ (*n*-butyl)
b	$\cdot CH_2 \cdot CH{:}CH \cdot CH_3$ (2-butenyl)
c	$\cdot CH_2 \cdot CH{:}CH_2$ (allyl)
d	$\cdot CH_2 \cdot C(CH_3){:}CH_2$ (2-methylallyl)
e	$\cdot CH_2 \cdot CH_2 \cdot CH{:}CH_2$ (3-butenyl)
f	$\cdot CH_2 \cdot CH{:}C(CH_3)_2$ (3-methyl-2-butenyl)
g	$\cdot CH_2 \cdot CH{:}CH_2$ (allyl)

$R' = CH_3$ in all compounds except *g*, where $R' = C_6H_5$. Compound b is structurally identical with cinerolone, but probably its geometric isomer. These substituted cyclopentenolones and also an uncyclized compound (formula II, where R and R' are as in Ic) were esterified with natural *d*-trans-chrysanthemum monocarboxylic



Formula II

acid. Compounds Ib and Ic were also esterified with the synthetic racemic (*dl*) *cis* and *trans* forms of this acid. Thus there were 12 new chemically pure compounds, closely related to cinerin I, available for comparison of toxicity.

Sprays were prepared by dissolving the compounds in refined kerosene at selected concentrations. Pyrethrum standards of comparison were prepared from a kerosene extract of pyrethrum flowers, and

chemical analysis (A.O.A.C. method) made during the tests showed that 56 per cent of the "total pyrethrins" consisted of pyrethrin I and cinerin I.

PROCEDURE.—The tests were made by the turntable method, on adult house flies, *Musca domestica* L., reared by standard procedure. Knockdown and mortality percentages were determined in as many replicated tests as possible at concentrations selected according to preliminary tests. Approximately 100 flies were used in each test. The average age of the flies in the daily test runs was 2, 3, or 4 days, being varied according to the expected resistance of the flies.

Since the materials were prepared at different times, the tests on them were begun immediately after their preparation to avoid any possible deterioration during storage. The tests were therefore made in several series, and the standard pyrethrum extract was included in each series. When not in use, the samples were kept in the refrigerator at 2° C.

RESULTS.—The toxicity data are summarized in table 1.

Table 1.—Toxicity to house flies of kerosene space sprays containing synthetic compounds related to pyrethrins.

Series and Number of Tests	Ester: Keto-Alcohol	Ester: Acid[1]	Concentration in Refined Kerosene	Knockdown in 25 Minutes	Mortality in 1 Day
			Mg. per Ml.	*Per Cent*	*Per Cent*
1-2	Ib	Natural	8.00	100	99
			4.00	100	86
	Ic	Natural	8.00	100	100
			4.00	100	100
	Standard		1.83	100	57
			0.92	100	22
2-1	Ic	Natural	2.00	100	100
			1.00	100	98
	Standard		0.92	100	52
3-6	Ib	Natural	4.00	100	74
			2.00	100	62
			1.00	100	37
	Ic	Natural	1.00	100	77
			0.50	100	58
			0.25	100	44
	Standard		3.66	100	66
			1.83	100	44
			0.92	100	24
4-2	Ib	*dl-cis*	4.00	100	48
			2.00	100	37
	Ib	*dl-trans*	4.00	100	53
			2.00	100	28
	Ic	*dl-cis*	1.00	100	41
			0.50	100	30
			0.25	92	20
5-5	Ib	*dl-cis*	8.00	100	75
			4.00	100	40
			2.00	100	25
	Ib	*dl-trans*	8.00	100	70
			4.00	100	54
			2.00	100	29
	Ic	*dl-cis*	2.00	100	80
			1.00	100	47
			0.50	100	34
	Ic	*dl-trans*	2.00	100	81
			1.00	100	58
			0.50	100	26
	Ie	Natural	8.00	100	89
			4.00	100	68
			2.00	100	39
			1.00	98	16
	Standard		7.32	100	92
			3.66	100	71
			1.83	100	55
			0.92	100	33
6-1	Ig	Natural	8.00	100	78
			2.00	91	11
	Id	Natural	8.00	100	100
			2.00	100	89
	Ia	Natural	16.00	100	45
			4.00	91	4
	If	Natural	8.00	98	49
			2.00	40	19
	IIc	Natural	16.00	92	10
2	Standard		1.83	100	58
			0.92	100	29
7-8	Ig	Natural	8.00	100	77
			4.00	100	40
			2.00	98	23
	Id	Natural	2.00	100	78
			1.00	100	65
			0.50	100	48
	Ia	Natural	32.00	100	89
			16.00	100	66
			8.00	100	35
	If	Natural	16.00	100	67
			8.00	100	45
			4.00	97	27
	IIc[2]	Natural	16.00	94	22
	Standard		7.32	100	89
			3.66	100	71
			1.83	100	47
			0.92	100	29

[1] The acid used was in all cases chrysanthemum monocarboxylic acid.

[2] An uncyclized compound, 3-hydroxy-8-nonene-2,5-dione.

DISCUSSION.—Certain relationships may be estimated directly from these data. However, to put the relationships on a more quantitative basis, the results in series 3, 5, and 7 were plotted on log-probability paper, and straight lines representing toxic action in the range studied were fitted graphically, as shown in figures 1 to 3. The relative toxicity of the compounds may then be expressed by the inverse ratios of the concentrations causing 50 per cent mortality of flies, each compound being compared with the standard pyrethrum extract in its own series. Such comparisons were made and the data are given in table 2. The relative standard errors for the estimated concentrations resulting from tests with 5, 6, and 8 replications were 7.3, 6.7, and 5.8 per cent, respectively. From these comparisons the relationships discussed below may be made.

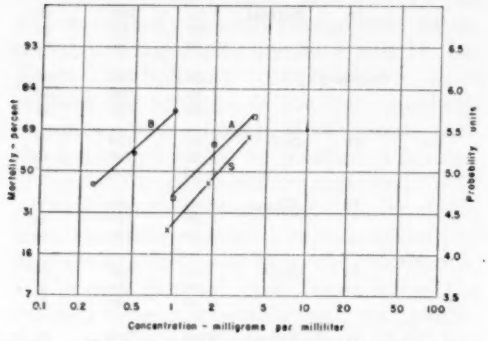


FIG. 1.—Toxic action of the esters of Ib and *d* acid (A), Ic and *d* acid (B), and the standard (S).

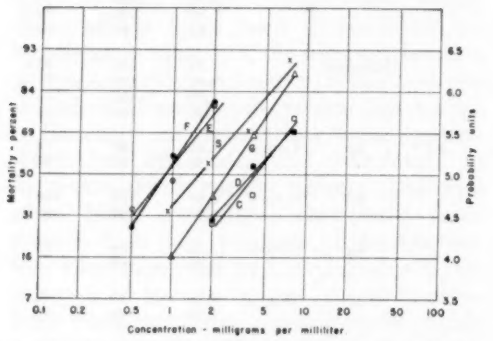


FIG. 2.—Toxic action of the esters of Ib and *dl-cis* acid (C), Ib and *dl-trans* acid (D), Ic and *dl-cis* acid (E), Ic and *dl-trans* acid (F), Ie and *d* acid (G), and the standard (S).

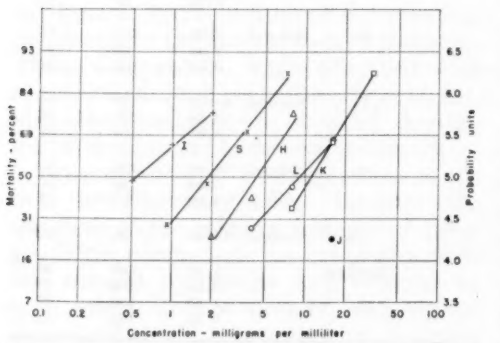


FIG. 3.—Toxic action of the esters of Ig and *d* acid (H), Id and *d* acid (I), IIc and *d* acid (J), Ia and *d* acid (K), If and *d* acid (L), and the standard (S).

Table 2.—Relative toxicity to house flies of synthetic compounds related to pyrethrins in kerosene sprays.

Ester		Mean Concentration Causing 50 Per Cent Mortality	Relative Toxicity
Keto-Alcohol	Acid	*Mg. per Ml.*	*Ratio*
		Series 3	
Ib	Natural (*d*)	1.49 ±0.10	1.48 ±0.14
Ic	Natural (*d*)	0.333± .022	6.64 ± .63
Standard		2.21 ± .14	1.00
		Series 5	
Ib	*cis* (*dl*)	4.20 ± .31	0.379± .039
Ib	*trans* (*dl*)	3.98 ± .29	0.399± .041
Ic	*cis* (*dl*)	0.883± .064	1.80 ± .19
Ic	*trans* (*dl*)	0.877± .064	1.81 ± .19
Ie	Natural (*d*)	2.59 ± .19	0.614± .063
Standard		1.59 ± .12	1.00
		Series 7	
Ig	Natural (*d*)	4.34 ± .25	0.433± .036
Id	Natural (*d*)	0.543± .031	3.46 ± .28
Ia	Natural (*d*)	11.20 ± .64	0.168± .014
If	Natural (*d*)	9.05 ± .52	0.208± .017
IIc	Natural (*d*)	>20.	<0.09
Standard		1.88 ± .11	1.00

The compound having the 2-butenyl side chain (Ib) and esterified with the natural acid, was relatively as toxic as was cinerin I, obtained by resynthesis of cinerolone with the natural acid (Gersdorff 1947)—1.5 and 1.4 times the standard, respectively. This relationship emphasizes the importance of the hydroxyl group being in position 4 of the nucleus of the cyclopentenolone component, since it was found (LaForge, Green, and Gersdorff 1949) that a compound differing from this component only in having the hydroxyl group in position 5 yielded a chrysanthemum monocarboxylic acid ester of considerably lower toxicity than cinerin I. It also shows that a geometric difference involving the unsaturated (2-butenyl) side chain of the cyclopentenolone nucleus is without influence on the toxicity of the two isomers.

The *d*-chrysanthemum monocarboxylic acid ester of the cyclopentenolone with the allyl side chain (ester of Ic and natural acid) was found to have the highest toxicity of any of the pyrethroids (compounds related to pyrethrins), natural or synthetic, known at present. Its toxicity was 6 to 7 times that of the standard pyrethrum extract. This places the compound at about 3 times the toxicity of pyrethrin I (Gersdorff 1947), which is rather surprising. Shortening of the side chain by one carbon atom with the loss of one double bond—that is, the change from pyrethrin I to cinerin I—decreased the toxicity to about two-thirds (Gersdorff 1947). Now it has been found that shortening of the side chain by one more carbon atom with the double bond now terminal—that is, the change from the 2-butenyl structure to the allyl structure—resulted in a nearly 5-fold increase in toxicity. This increase was found to be independent of the form of the acidic component. The ratios for the corresponding pairs with the same form of acid component were 4.5, 4.7, and 4.5 for the esters of the natural, *cis* synthetic, and *trans* synthetic acids, respectively.

The need of at least one double bond in the side chain is shown when the toxicity of the *n*-butyl compound (ester of Ia) is compared with that of the corresponding 2-butenyl compound. Saturation of the side chain has decreased the toxicity to one-ninth. It has been shown previously (Gersdorff 1947) that saturation of the side chain in the pyrethrin I molecule also decreases toxicity greatly.

In the compounds prepared by esterifying two of the cyclopentenolones (Ib and Ic) with synthetic chrysanthemum monocarboxylic acids, the ester prepared from the *cis* form of the acid did not differ in toxicity from its isomer prepared from the *trans* form. However, for the compounds with both types of side chain, toxicity was lower when the racemic synthetic acid was used than when the dextro natural acid was used. The latter formed esters nearly 4 times as toxic as were formed by the racemic acids, the ratios being 3.8 for the 2-butenyl compounds and 3.7 for the allyl compounds. However, the completely synthetic allyl compound was very toxic, practically as toxic as pyrethrin I.

The introduction of a methyl group on the 2-carbon atom in the allyl side chain (Id) decreased toxicity about one-half for the esters from the natural acid, but this methylallyl compound was still nearly twice as toxic as pyrethrin I.

The introduction of a second methyl group on the 3-carbon atom of the side chain of the 2-butenyl compound (If) was accompanied by a decrease in toxicity to one-seventh when the natural acid formed the acid component.

The substitution of the phenyl group for the methyl group on the 3-carbon atom in the cyclopentenolone nucleus of the allyl ester (ester of Ig) decreased toxicity to one-fifteenth when the natural acid formed the acid component.

The uncyclized compound (ester of IIc) was less than one-seventieth as toxic as the corresponding cyclized compound (ester of Ic and natural acid).

All these esters, even the uncyclized compound, had high knock-down value. When the knock-down was below 100 per cent, in general knock-down effect paralleled lethal effect, the least toxic compounds having the lowest knock-down value and in the same order. The same relationship is shown when the two butenyl compounds with the acyl group attached to position 4 of the cyclopentenolone nucleus (Ib and Ie) are compared to the corresponding isomers with the attachment in position 5 (LaForge *et al.* 1949).

SUMMARY.—The relative toxicity to house flies, *Musca domestica* L., of certain new synthetic compounds related to pyrethrins was determined by the turntable method.

The *d*-chrysanthemum monocarboxylic acid ester of synthetic 2-(2-butenyl)-4-hydroxy-3-methyl-2-cyclopenten-1-one (probably a geometric isomer of cinerolone) was as toxic as natural cinerin I, about one and one-half times as toxic as the mixture of "pyrethrins" contained in the ordinary pyrethrum-kerosene extract.

The replacement of the 2-butenyl side chain of these compounds with the allyl group was accompanied by a nearly 5-fold increase in toxicity whether the acid component was the dextro natural one or a racemic *cis* or *trans* synthetic one. The allyl compound with the natural acid component was the most toxic of any of the known pyrethroids, 6 to 7 times as toxic as the mixture of "pyrethrins."

No difference in toxicity was found between the compounds of the *cis* and *trans* forms of the acid component for both

classes of compounds, the 2-butenyl and the allyl.

For both classes the ester with the natural dextro acid component was about 3.8 times as toxic as an ester with a synthetic racemic acid component.

The completely synthetic isomers of cinerin I were about 0.39 times as toxic as the mixture of "pyrethrins."

The completely synthetic allyl compounds were about 1.8 times as toxic as the "pyrethrins."

The effect of other changes in chemical structure on toxicity was determined.

Knock-down effect was of high order for all the compounds.

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CUMULATIVE LIST OF NEW MEMBERS AND OTHER NAMES NOT INCLUDED IN THE OFFICIAL ROSTER FOR 1949

ADDITIONS TO MEMBERSHIP LIST

(to June 27, 1949)

The Committee on Membership has considered and unanimously approved the following persons for membership in the American Association of Economic Entomologists.

HARVEY L. SWEETMAN, CHAIRMAN,
Committee on Membership

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W. H. Aldrich
C. W. Anderson
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J. E. Lane
W. B. Lattimore, Jr.
M. A. Leraas
L. R. Lewallen
F. T. Lind
A. J. Lloyd
G. E. Mack
C. H. Mahoney
F. O. Marzke
A. P. Morris
B. V. Nardy
D. D. Nelson
T. D. Nolen
H. D. Purswell
D. B. Reddy
B. E. Rees
F. P. Roullard
A. B. Ruppenthal
R. Russell
D. K. Scharff
D. L. Schuder
H. R. Shepherd
R. E. Siverly
D. A. Sleeper
F. K. Steinrock
E. A. Taylor
R. K. Thompson
R. Thurston
K. Todd
H. Townes
O. Fuentes del Valle
I. H. Waller
N. Weaver
E. C. Wegeneck
R. D. Wessel
E. L. Wilson

The following members have been reinstated.

R. K. Vorhees, Lake Alfred, Florida
Fred B. Jacobson, 1827 Chestnut St., Philadelphia 3, Pa.

Automatic Traps for Killing Japanese Beetles[1]

ENGEL GILBERT, GEO. S. LANGFORD, and R. H. VINCENT, *University of Maryland, College Park*

During the past 8 years approximately 50,000 traps have been used annually in Maryland as an aid in the control of the Japanese beetle. Research at the University of Maryland for several years has had as one of its objectives the development of a trap that would not need emptying. With the advent of DDT, Langford & Muma (1945), reported on the use of traps which would automatically kill beetles passing through it and thereby eliminate much of the labor and time consumed in visiting the traps and destroying the captured beetles. Although these traps (Fig. 1 and 2) killed from 95 to 100 per cent of all beetles passing through them it was felt they could be simplified and thus reduce their cost. To this end two modifications were made and tested.

The first modification (Fig. 3) was to combine the attractant with the killing agent and replace the standard baffle with a solid one. The second modification (Fig. 4) was the replacement of the funnel with a flat metal plate on which a killing agent could be placed.

Both modifications showed a high degree of efficiency. Modification No. 1 killed from 84 to 93.7 per cent of all beetles passing through. The results obtained with Modification No. 2 were more variable. The type of material used with DDT as a killing surface appeared to have an important bearing on results. Where soft corrugated cardboard or blotting paper was impregnated with a saturated solution of DDT in ether, kills of 94 to 97 per cent were obtained.

MODIFICATION No. 1.—This modification was designed to combine the attractant and the killing agent. A total of eight bait combinations were used (Table 1). Sufficient DDT (technical) was added to each bait to make a 5 per cent DDT solution. These DDT-bearing bait combinations were placed at the bottom of trap funnels (Fig. 3), and were tested for efficiency against identical bait combinations without DDT; and against automatic traps (Fig. 4), which carried the attractant in the baffle and the killing agent, 5 per cent DDT in *Deobase* oil, at the bottom of the funnel. All traps were replicated at least once and operated in linear batteries with traps spaced at intervals of 8 feet.

The beetles passing through the traps were collected in clean screened cages and counted daily. Twice weekly all cages were soaked in *Deobase* oil, washed and rinsed to eliminate any possible DDT residue.

All tests in which DDT was combined with baits gave a high degree of kill. Table 1 gives the details. DDT combined with geraniol and eugenol appeared most

[1] Eastern Branch Program.

Table 1.—Results obtained with automatic traps in which bait and attractant was combined. Modification No. 1. (Tests continued 9 weeks; June 26 to Aug. 29, 1946.)

MATERIALS	BEETLES PER TRAP (AVERAGE)	PER CENT KILLED
1. Standard (9 parts geraniol, 1 part eugenol); DDT 5 per cent	47,223	93.7
2. Caproix acid, 8 parts; eugnol, 1 part; phenyl ethyl butyrate, 1 part; DDT 5 per cent	48,309	90.3
3. Caproic acid, 9 parts; eugenol, 2 parts; DDT 5 per cent	10,920	87.2
4. Caproic acid, 8 parts; phenyl ethyl butyrate, 2 parts; DDT 5 per cent	20,041	90.2
5. Caproic acid, 8 parts; equal parts geraniol, eugenol, phenyl ethyl butyrate, 2 parts; DDT 5 psr cent	16,320	89.6
6. Anethol, 4 parts; caproic acid, 4 parts; eugenol 1 part, phenyl ethyl butyrate, 1 part; DDT 5 per cent	34,213	91.6
7. Anethol, 4 parts; caproic acid, 4 parts; eugenol, 2 parts; DDT 5 per cent	31,274	85.7
8. Anethol, 9 parts; eugenol, 1 part; DDT 5 per cent	40,838	84.0
9. Using the above 8 mixtures of baits in the typical automatic trap (bait above, killing agent below) with 5 pr cent DDT in Deobase oil as killing agent. Two traps of each	31,146.6	98.6
10. Checks using typical automatic traps without killing agent	23,520.6	5.5

Table 2.—Use of automatic traps having funnel replaced with a flat metal plate. (Modification No. 2.)

No.	Materials	Beetles Counted	Per Cent Killed
1.	Soft corrugated paper soaked in saturated solution of technical DDT in ether	2139	97.0
2.	Soft corrugated paper soaked in saturated solution of technical DDT in ethylene dichloride	712	87.6
3.	Soft corrugated paper soaked in saturated solution of technical DDT in 1 part axle grease and 2 parts ethylene dichloride	4092	96.8
4.	Soft absorbent blotter soaked in saturated solution of technical DDT in ethylene dichloride	1342	96.9
5.	Desk blotter soaked in saturated solution of technical DDT in ether	3582	94.0
6.	Smear of 3 parts axle grease, 8 pars of 50 per cent wettable DDT	496	83.8
7.	Tar paper soaked in saturated solution of technical DDT in ethylene dichloride	166	62.0
8.	Tar paper soaked in saturated solution of technical DDT in 1 part axle grease and 2 parts ethylene dichloride	208	74.5
9.	Desk blotter soaked in saturated solution of technical DDT in ethylene dichloride	171	73.7
10.	Desk blotter soaked in saturated solution of technical DDT in 1 part axle grease and 2 parts ethylehe dichloride	239	77.8
11.	Cardboard box paper soaked in saturated solution of technical DDT in ethylene dichloride	195	73.8
12.	Cardboard box paper soaked in saturated solution of technical DDT in 1 part axle grease and 2 parts ethylene dichloride	188	83.5
13.	Cotton wicking soaked in thin paste of 50 per cent wettable DDT in ethylene dichloride	192	89.6
14.	Cotton wicking soaked in saturated solution of technical DDT in ethylene dichloride	163	65.1
15.	Sponge rubber soaked in saturated solution of technical DDT in ethylene dichloride	210	63.8
16.	Three check traps of typical automatic type with salve-can using 1 part technical DDT and 2 parts axle grease	75,207	99.4

effective. It killed 93.7 per cent of the beetles passing through the traps. Other combinations were slightly less effective. Greater efficiency was obtained in those traps where the attractant and killing agent were separated. These combinations averaged a kill of 98.6 per cent of all the beetles passing through the traps.

MODIFICATION NO. 2.—This modification (Fig. 4), was designed to produce a

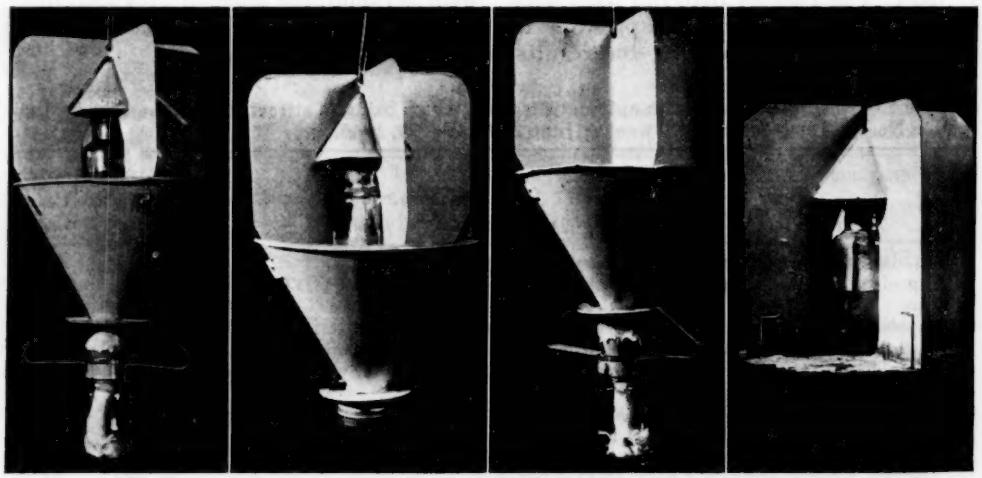

FIG. 1.—I. Automatic trap. Attractant at top, killing fluid at bottom. II. Automatic trap. Attractant at top, solid killing medium at bottom. III. Modification No. 1. Automatic trap. Bait and killing agent combined at bottom, standard baffle replaced with solid one. IV. Modification No. 2. Automatic trap. Funnel replaced with a flat metal plate on which killing medium is placed.

very simple trap at a minimum cost. The effectiveness of this trap appears to be dependent on the type of killing surface used and the method in which it was treated with DDT.

These traps were set in batteries and allowed to operate. The number of beetles dying on the killing surface was negligible. This in no case was sufficient to impair the effectiveness of the trap. Readings on the efficiency of the traps were made in two ways. In one group of traps (Table 2, traps 1 to 6), records were made on beetles collected in a special designed cage placed beneath the trap to catch and hold all beetles falling from the killing surface. In the other group (Table 2, traps 7 to 15), data was collected twice a week by capturing beetles as they alighted. All beetles were held for 24 hours to determine whether or not they lived.

Table 2 gives the results obtained with different killing surfaces. In most instances the kill was as high at the end of the season as at the beginning. Killing efficiency ranged from 62 to 97 per cent depending on the kind of killing surface and the method by which it was treated with DDT. Best results were obtained with a killing surface prepared by treating soft corrugated cardboard with a saturated solution of DDT in ether.

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HARRY B. WEISS HONORED

Harry B. Weiss, Director of the Division of Plant Industry, New Jersey Department of Agriculture, was presented with a citation and the gold medallion of the New Jersey Agricultural Society at the annual meeting of the Society in Trenton, New Jersey, on May 9, 1949.

An appropriate leaflet bearing a full page picture of Mr. Weiss and a reproduction of the obverse and reverse faces of the medallion, along with the text of the citation, were included in the leaflet. The text of the citation is reproduced below:

HARRY B. WEISS

FOR nearly forty years you have served loyally the diversified agricultural interests of New Jersey, filling with distinction your important post in the State Department of Agriculture where you have directed the plant pest control program.

You have performed your duties with efficiency and quiet courtesy, always eager to aid those confronted with difficult insect and plant disease problems. Under your administration the gypsy moth was eradicated, the Japanese beetle has been suppressed and no serious economic pest has established a foothold in New Jersey.

Your devotion to your chosen field of entomology has known no limitations. Colleagues throughout the nation long have commended your tireless research particularly in assembling the older treatises on insects in many lands.

As the author of nearly one thousand published articles dealing both with a wide variety of scientific subjects and many of the lesser known personalities of science, you have made a substantial contribution to the annals of natural life. You have dedicated years of volunteer service guiding the activities and keeping house for the regional and national entomological associations.

In a lighter vein but with the same zeal for accuracy and comprehensive research, you have directed your talents toward more commonplace subjects. Your humorous treatment of such interesting historical data has delighted countless readers.

In keeping with the traditions of the New Jersey Agricultural Society which since 1871 has fostered agricultural research and the betterment of rural living, the Medallion of the Society is awarded to you, its able historian, as a tribute to your many outstanding achievements."

SCIENTIFIC NOTES

Bassus diversus, an Oriental Fruit Moth Parasite Established in the United States

H. W. Allen and W. P. Yetter, Jr.,[1] *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Bassus diversus Mues. was first imported into this country in 1933 from Japan. There it had been found at only a few localities as a minor parasite of the oriental fruit moth, *Grapholitha molesta* (Busck). From 1934 to 1939 large numbers of this parasite were propagated at Moorestown, N. J., and widely colonized over the eastern United States. Immediately after release it freely attacked oriental fruit moth larvae in peach twigs, and parasitization in excess of 20 per cent was not uncommon in orchards that had been colonized. Although the immediate results were highly favorable, the rates of parasitization invariably decreased in the succeeding generations. A few single specimens were recovered from larvae in peach twigs a year after colonization, but finally the parasite seemed to have disappeared from the twig-infesting larvae of peach.

Colonization of *Bassus diversus* in southern New Jersey was discontinued in 1939. During the following 8 years none of these parasites were reared from the many thousands of oriental fruit moth larvae infesting peach twigs that were collected from orchards in this area. However, since 1943 information has been obtained which leads to the conclusion that this imported species is now firmly established in New Jersey.

Late in September 1942, about 2.5 bushels of Krummel peach drops were collected from two orchards at Moorestown, and from them the oriental fruit moth larvae were reared and overwintered in the cocoon stage. In the spring 39 parasites were obtained in a total emergence of 468 specimens. Seven of the parasites were *Bassus diversus*.[2] This recovery was made more than 3 years after liberations had been terminated. In the fall of 1943 *B. diversus* was again recovered from oriental fruit moth larvae reared from late peach drops and overwintered in the cocoon stage. However, only one specimen was obtained from 1707 cocoons. In 1947, 8 years after the last liberations of *B. diversus*, several bushels of late peach drops were collected from two locations, about 5 miles apart, in the vicinity of Moorestown. Several hundred oriental fruit moth larvae were obtained from these drops and overwintered in the cocoon stage. Early in the spring of 1948, 53 parasites were reared from this material, of which 50 were *B. diversus*.[2] The parasite was recovered from both locations.

Although in its native home this species parasitized the oriental fruit moth larvae infesting peach twigs in spring and midsummer, it apparently followed this habit only for a short time after it was liberated at Moorestown. It now appears to restrict its parasitization to the larvae attacking peaches in late summer and early fall.

The recovery from overwintered cocoons indicates that locally it is a fairly common parasite of such material. In marked contrast is its absence from other sources of oriental fruit moth. From 1940 to 1943, inclusive, during spring and midsummer 37,600 fruit moths were reared from infested peach twigs and 17,700 from immature peach drops from numerous orchards in New Jersey. Not one *B. diversus* was ever recovered from them. In the fall of 1943 about 800 hibernating oriental fruit moth larvae were obtained from apple drops on property where *B. diversus* had previously been recovered from late peach fruits. No *Bassus* parasites were obtained from these drops. Their relative abundance in overwintering oriental fruit moth larvae from peach fruits indicates that there must be a suitable alternate host during the long intervening period. This alternate host has not yet been discovered.

[1] The information in this paper was obtained by the authors and M. H. Brunson, G. J. Haeussler, and E. L. Plasket.
[2] Identified by C. F. W. Muesebeck.

A Japanese Weevil Appears in Damaging Numbers

H. W. Allen, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

In July 1946 a weevil was found at Moorestown, N. J., feeding heavily on a hedge of California privet, on one property located on the south side of a block near the West Moorestown Station of the Pennsylvania Railroad. Specimens were sent to the Division of Insect Identification, Bureau of Entomology and Plant Quarantine, where they were identified by L. L. Buchanan as *Pseudocneorrhinus bifasciatus* Roelofs, an introduced Japanese species. C. F. W. Muesebeck informed us that this insect was first found in this country in 1914, in the vicinity of Philadelphia, Pa., and has since been collected at scattered locations in Connecticut, New York, Pennsylvania, and the District of Columbia. Reports indicate damage to a few plant species, and scattered feeding on several others. He also stated that in American literature it has been misidentified as *P. setosus* Roel. Britton (1932) reported an instance of damage to Japanese barberry, California privet, lilac, and hemlock on a property at West Haven, Conn., in 1932, but since that time it seems not to have been mentioned in economic literature.

In August 1948, this insect was again found feeding in large numbers on one property at Moorestown, located on the northwest corner of the same block in which the 1946 infestation occurred. About 50 feet of California privet hedge had been almost completely defoliated, and a moderate amount of feeding was in progress on nearby lilac, Japanese barberry, rose, perennial veronica, geranium, and lily-of-the-valley. Hundreds of weevils were jarred from the infested plants. In feeding, the beetles had cut broad rounded sections from the margins of the leaves, which, in areas of heavy feeding, gave the foliage a peculiar crenulated appearance. Preliminary tests with several insecticides indicated that chlordan was likely to prove more effective than benzene hexachloride, DDT, or arsenate of lead in controlling this weevil.

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Termite Treatment with Aqueous Solution of Chlordan

V. E. SHELFORD

In Urbana, Illinois, a termite swarm from near a chimney led to the discovery that dead and partially dead stubs of *Forsythia* sp., set on three sides of the square house, left by cutting back the older stalks, were all tunnelled by termites. This plant has a hollow in the center of the woody stem. Stubs of *Parthenocissus tricuspidata* (Boston Ivy), *Symphoricarpos albus* (snow berry) and *S. orbiculatus* (coral berry), *Spiraea* sp., *Ligusturm* sp. (privet), growing close to the *Forsythia* were untouched. A stump of tree of heaven (*Ailanthus*) partially surrounded by a living tree was heavily infested and tunnelled along with the trunk and roots of half dead trees. A cherry tree 65 feet from the rear of the house with a concrete repair in one side and a partially rotten heart was infested with termites, and, as was shown later, also with carpenter ants, *Camponotus pennsylvanicus*, and two smaller species of ants not identified. The tunnels of the several species were separated by the vascular rays of the wood.

The termites had evidently not gotten into the house proper but only in the lower wooden step of a porch. However it was decided to try an experiment with aqueous solution of chlordan. All the *Forsythia* within 15 feet of the house was completely removed as were the ailanthus trees and their roots and stumps. The soil was treated with 0.25 per cent solution of chlordan.[1] It was then proposed that a routine treatment of the house be carried out with 1 per cent chlordan in aqueous emulsion.[2] The outside of the wall was treated[3] with special equipment which put the liquid near the bottom of the foundation under pressure from a special pipe thrust down to that level. The writer and the owner of the house treated the interior of the foundation, the porch footings and chimney bottoms. The work was completed early in September, 1947.

The first soil tests were made November 6 to 10, 1948 to determine the extent of toxicity after this period had elapsed. To test the soil about 4 c.c. of soil to be tested was put into a 22 cc. homeopathic vial and in each case a check vial was prepared in the same manner using garden soil or sand mixed with a little garden soil. The vials were tightly corked. The only possible food for the termites was a strip of heavy manila paper 4 mm wide and 50 mm long on which essential data were recorded.

The control specimens in the mixture of sandy garden soil were alive and active after 10 days. Specimens collected for the experiment were alive after a month though enclosed in a tight salve box with a few slivers of wood.

About October 1, 1947, several types of wood were placed near an old colony of termites located under a glass roofed building. The wood consisted of stakes of cherry, *Forsythia* and *Ailanthus* and a piece of each cherry and *Ailanthus* trunk, about 8 by 12 inches and one of each 6 inches square. An examination of these was made on Nov 5, 1948. The small pieces of both woods were completely riddled. The large piece of *Ailanthus* was heavily damaged. The large piece of cherry trunk was still heavy and apparently untouched although 2 weeks after the pieces were put on the soil, all had large numbers of termite workers under them. The *Ailanthus* stake had been tunnelled throughout its length and sealed over at the top. The cherry stake was eaten at the bottom. The small available *Forsythia* twigs and stakes were less damaged. The 2 by 2 inch marker and sign bearing stakes were most damaged. The stakes and wood were left in place but will be renewed after another year if materials are available.

The old cherry tree was treated by boring three holes into the dead wood above the concrete patch and introducing 2 gallons of 0.25 per cent aqueous chlordan. An inspection of the low part of the decayed center showed all termites and small ants dead. The large black carpenter ants wiggled out of one of the top openings and fell to the ground, moving only their appendages. The total that came out during 3 days nearly filled a 500 cc graduate.

According to the agreement among the several parties concerned with the experiment there will be another report in October or November of 1949. The chlordan has held up well for the first year. The evidence of a preference of the termites for *Forsythia* is quite good at the time of discovery of the insects. It is not reinforced by the results with dead stalks but it may have come about through the properties of the live plants. The *Ailanthus* wood appears to be preferred over cherry for the first year of observation.

[1] Supplied by Dr. W. C. Kearns of the Department of Entomology, University of Illinois.

[2] Chlordan supplied by the Velsicol Corporation, the emulsifier was supplied by the Atlas Powder Co., and the emulsion was prepared by Mr. W. N. Bruce of the Natural History Survey.

[3] By the Illini Pest Control and Service Corporation, courtesy of W. K. Delaplane, Jr.

Table 1.—Chlordan effects 13 months after treatment. All termites showing paralysis died in about 24 hours.

		Experiments			Control			
Expt. Number	Date	Depth in inches	Distance from wall in inches	Hours to Paralysis	at end hours 24	48	72	96
1	Nov. 5	0.5	0.5	2	OK	OK	OK	OK
2	Nov. 5	4	0.5	3	OK	OK	OK	OK
3	Nov. 6	5	5	30	OK	OK	OK	OK
4	Nov. 6	4	2	24	OK	OK	OK	OK
5	Nov. 10	3	0.5 W	18[1]	OK	OK	OK	OK
6	Nov. 10	3	0.5 E	18[1]	OK	OK	OK	OK

[1] No observations between third and eighteenth hrs.; some specimens staggering after 3 hours. The soil of numbers 5 and 6 was so dry it was necessary to add water. A uniform dosage of the soil surface was not practicable.

Tests of Parathion for Control of the Little Fire Ant

MAX R. OSBURN, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

The little fire ant, *Wasmannia auropunctata* (Roger), is an important pest to workers in citrus and guava groves in southern Florida. In some groves great numbers of these ants are present on the trees and it is impossible for workers to pick fruit, prune, or spray without being covered with them and being stung many times. Fruit-picking crews have refused at times to work in infested trees. Additional information on the habits and importance of the little fire ant in citrus and guava groves has been published by Spencer (1941), Osburn (1945, 1948), and Wolfenbarger (1947). The use of DDT, chlordan, or toxaphene has prevented troublesome infestations of this ant when the material was thoroughly applied to the trunks and larger branches of citrus trees (Osburn 1948).

Parathion, one of the most potent of the new organic insecticides, was tested for its effectiveness against the little fire ant in St. Lucie County, Florida, during 1948. The results of these tests are reported in this paper.

The parathion was applied with a power sprayer to orange trees at two concentrations, 1 or 2 pounds of 25 per cent wettable powder per 100 gallons of water, and by two different methods. One method consisted of spraying the entire tree thoroughly and the other of covering only the tree trunk. The entire-tree coverage required 8 gallons of diluted material per tree and the tree-trunk treatment only about 2 gallons. The entire-tree coverage method was included in the experiment because of the recent promising results we had obtained with parathion for the control of several insects, other than the little fire ant, that infest citrus trees. We thought that if parathion proved to be satisfactory for control of the little fire ant, applications of the material to the entire tree might provide simultaneous control of several pests, and separate treatments for the ant might not be necessary.

The experimental design was that of randomized blocks. There were five replications for four treatments and a check, and a single tree in each block received each treatment. The treatments were evaluated at intervals after the applications by comparing the numbers of ants crossing 1-inch white bands that had been painted around each tree trunk before the sprays were applied. The data were analyzed statistically.

A summary of the results is presented in table 1.

Highly significant differences were demonstrated between infestations in the check and those in each of the treatments on each observation date. There were no significant differences between any of the treatments. Even though all treatments were highly significantly better than the check on each date, none of them would be considered satisfactory from the standpoint of a grove worker after the first few weeks, since comparatively small numbers of the little fire ants may be troublesome. The 1-pound concentration applied to the tree trunks was satisfactory until July 26, whereas the same concentration applied to the entire tree and the 2-pound treatments applied by either method gave satisfactory reductions until August 24.

The results of tests of parathion against citrus pests other than the little fire ant suggest that this material may have a place in the regular citrus spray schedule if it can be used safely. If such should be the case, considerable incidental control of the little fire ant would probably result. Thorough application of parathion to the entire tree for other pests could be expected to take care of the little fire ant for about 8 weeks. This control would mean a considerable saving to some citrus growers. Of course, if the little fire ant is the only pest to be considered, the 2-pound concentration applied to the trunks would be the most satisfactory of parathion treatments tested.

Parathion is a highly toxic material. Spray crews should take every precaution to avoid breathing vapors of parathion and getting it on their skins. Shirts should be buttoned at the neck and sleeves rolled down and buttoned at the wrist. Immediately upon the completion of a spray operation, the hands and face should be washed thoroughly with soap and water. The clothing should be removed and washed before it is worn again.

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Table 1.—Numbers of little fire ants crossing sample areas on orange trees at intervals after treatment on June 28, 1948 with sprays containing parathion.

PARATHION, 25% WETTABLE POWDER PER 100 GAL.	PART OF TREE	JULY 12	JULY 26	AUG. 9	AUG. 24	SEPT. 7
2 lbs.	Entire tree	0	0	1	12	170
	Trunk only	0	0	2	12	145
1 lb.	Entire tree	0	0	2	21	209
	Trunk only	1	16	18	47	261
Check, unsprayed		436	782	351	330	889
Difference required for significance at 1% level		74	113	121	145	291

Accumulated Residues of Insecticides Tested to Control the Orange Tortrix on Red Raspberries[1]

CARL JOHANSEN[2] and E. P. BREAKEY[3]

Tests were made of several insecticides in 1948 to determine the best possible timing of applications for the control of the orange tortrix, *Argytotaenia citrana* Fern., on red raspberries, with special reference to the accumulation of toxic residues on the fruit. Prior to this time, recommendations for the control of this insect allowed no insecticide applications after the blooming period, because of the uncertainty concerning the toxic residues which might remain on the fruit. The materials chosen were those which had shown the most promise in previous work.

A plot containing nine 138 foot rows of the Washington variety of red raspberry was used in the tests. Three insecticides were applied according to 3 schedules of 4 replicates each, making a total of 12 replicates for each material. Each replicate consisted of 33 to 36 feet of row containing 10 or 11 hills of raspberries. The replicates were randomized and were marked with painted stakes to facilitate spraying.

MATERIALS.—The following materials and dilutions were used in the tests: cryolite, 90 per cent sodium fluoaluminate, 2 lbs. per 100 gallons of water; 50 per cent wettable dichlorodiphenyl dichloroethane, 2 lbs. per 100 gallons of water; and parathion, 25 per cent wettable diethyl p-nitrophenyl thiophosphate, 0.3 llb. per 100 gallons of water.

METHODS.—These sprays were applied with a 100-gallon sprayer using a single hose and a berry gun. A canvas baffle was used to deflect the spray drift and keep the insecticides in the proper replicates. The sprays were applied at the rate of 200 gallons per acre.

Applications were made according to the schedules given in table 1. It will be noted that schedule 1 ended June 4, which was about the middle of the blooming period, the latest application date according to previous recommendations. Schedule 2 ended June 18, two weeks later than the first schedule. Schedule 3 ended July 2, one week before harvest began and four weeks after the close of schedule 1. The object, as has been stated, was to learn what effect these late applications would have on the accumulated residues remaining on the fruit at harvest time.

Duplicate samples of 1 quart each of ripe berries were taken from each set of replicates July 9, when harvest started. One set of samples was tested for spray residue by Vernon L. Miller, Western Washington Experiment Station Chemist, the other set was tested by Forest J. Goodrich and William Roth, Chemists with the Food and Drug Division, Washington State Department of Agriculture, Seattle, Washington.

RESULTS.—The results of these tests are given in table 2. This table is largely self explanatory. It may be noted, however, that the chemists are in close agreement and that the residues did not accumulate as was anticipated.

These results should enable us to recommend late applications (14 days before picking) of dichlorodiphenyl dichloroethane for the control of the orange tortrix in 1949. In other tests, dichlorodiphenyl dichloroethane has given the most consistently good results and the best residual action of the various insecticides tried.

[1] Published as Scientific Paper No. 826, Agricultural Experiment Stations, Institute of Agricultural Sciences, State College of Washington. Address authors at Western Washington Experiment Station, Puyallup, Washington.

[2] Assistant in Entomology, Washington Agricultural Experiment Stations.

[3] Associate Entomologist, Washington Agricultural Experiment Stations.

Table 1.—Schedules for spray applications, residue tests, 1948.

SCHEDULES	MATERIALS	APPLICATIONS	REPLICATES	SAMPLES
1	Cryolite	April 22, May 10, June 4	4, white stakes	C_1
	Dichlorodiphenyl dichloroethane	April 22, May 10, June 4	4, white stakes	R_1
	Parathion	April 22, May 10, June 4	4, white stakes	P_1
2	Cryolite	May 10, June 4, June 18	4, red stakes	C_2
	Dichlorodiphenyl dichloroethane	May 10, June 4, June 18	4, red stakes	R_2
	Parathion	May 10, June 4, June 18	4, red stakes	P_2
3	Cryolite	June 4, June 10, July 12	4, blue stakes	C_3
	Dichlorodiphenyl dichloroethane	June 4, June 10, July 12	4, blue stakes	R_3
	Parathion	June 4, June 10, July 12	4, blue stakes	F_3

Table 2.—Residue Analyses Tests by Experiment Station Chemist.

SAMPLES	C_0[2]	C_1	C_2	C_3	R_0	R_1	R_2	R_3	P_0	P_1	P_2	P_3
RESIDUES (ppm)	0.4	0.7	2.0	7.0	1.0	1.0	6.0	12.0	—[1]	0.025	0.035	0.1

Tests by State Food and Drug Division Chemists.

SAMPLES	C_0	C_1	C_2	C_3	R_0	R_1	R_2	R_3	P_0	P_1	P_2	P_3
RESIDUES (ppm)	0.6	0.6	1.3	5.4	2.0	2.1	4.0	12.5	0.0	—[1]	0.019	0.068

[1] Could not read (other results for parathion so small that couldn't be read too accurately).

[2] C_0, R_0, P_0, are check samples, berries which had not been sprayed.

Experiments to Control Aphids on Shade-Grown Tobacco

F. S. CHAMBERLIN, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*[1]

Aphid infestations, consisting mainly of *Myzus persicae* (Sulz.), have recently become an important menace to the production of shade-grown cigar-wrapper tobacco in Florida and Georgia. Control measures being developed indicate that these infestations may be held below the level of economic importance. The following experiments carried out at Quincy, Florida, during the 1948 growing season are a contribution to this effort.

The 1-acre experimental shade field was divided into three blocks of plots separated by roadways. Each plot was 7 rows wide and 38 feet long, and the plots were 8 feet apart. Treatment and check plots were located at random. Seven treatments and two checks were included in each block.

Tobacco plants of the RG variety were set in the field on March 26. Soon after they had become established, aphid-infested seedling leaves were scattered throughout the field until a heavy, general infestation was present on the plants. The population was allowed to increase until April 19, when the first applications of insecticides were made. The six untreated check plots and the plots receiving the nicotine dust became very heavily populated with aphids and produced an abundance of winged forms. These winged aphids were a constant source of reinfestation on nearby treated plots during the greater part of the growing season. These conditions imposed an unusually severe test on the materials.

All the test materials were applied in dust form by means of rotary hand dusters. Applications were made between 7 and 9 A.M., at which time the air was generally calm and tobacco foliage was slightly damp with dew. The application dates were as follows: parathion mixtures, April 19, 26, May 10, 24, and June 14; gamma benzene hexachloride, April 19, 26, 30, May 4, 10, 17, 24, 31, and June 14; nicotine, April 19, 26, 30, May 4, 10, 17, and 24.

As shown in table 1, five applications of parathion dust of 1 per cent concentration held the aphids to extremely low population levels through the growth period. No aphid damage was sustained on any of the plots treated with this material. There was little apparent variance in the results obtained with different rates of application and formulations of the insecticides, including admixtures with chlordan and with DDT. As different amounts of the materials were applied, the results are not strictly comparable. None of these treatments caused apparent injury to the growing plants. The parathion applications remained effective for about two weeks.

Applications of the nicotine dust failed to control the aphids in this experiment. The treatments reduced the population by about 48 per cent as compared with that of untreated plots, but surviving infestations were sufficient to ruin the tobacco.

Under conditions of this experiment where severe infestations were artificially produced the nine seasonal applications of a commercial dust containing essentially pure gamma benzene hexachloride failed to give practical control of aphids. Tobacco on the treatment plots sustained an estimated loss of 75 to 85 per cent. The large amounts of this material applied to the tobacco foliage left a disfiguring residue.

The tobacco on all six untreated check plots was ruined by aphids by the middle of the growing season. Many of the plants had been stunted to half their normal size. Characteristic injury symptoms included stunted growth, necrotic areas in the leaves, considerable amounts of honey dew which prevented normal curing, and disfiguring aphid skins and sooty mold.

[1] In cooperation with the North Florida Agricultural Experiment Station.

Table 1.—Results of tests in control of aphids on shade-grown tobacco.

Treatment, Applications and Gounds per Acre			Aphids per 25 Leaves[1]											Commercial Damage
			April		May					June				
			22	29	3	6	13	20	27	3	10	17	24	
Parathion 1%: In pyrophyllite	5	123	0	0	2	21	1	10	2	0	33	0	1	None
In pyrophyllite and tobacco dust	5	169	0	T[5]	3	12	0	3	T	0	8	0	0	None
Parathion 1%+chlordan 5% in pyrophyllite and tobacco dust	5	197	T	0	11	19	T	11	0	0	0	0	0	None
Parathion 1%+DDT 10% in pyrophyllite and tobacco dust	5	122	0	0	5	26	1	7	3	0	3	0	0	None
Parathion 1%+DDT 10% +chlordan 5% in pyrophyllite and tobacco dust	5	157	0	1	3	32	3	3	1	T	40	0	0	None
Gamma benzene hexachloride (essentially pure) 1.5%[2]	9	501	555	1104	764	447	704	2649	1193	24	98	114	438	75–85%
Nicotine 5%[3]	7	373	664	3280	3023	2111	3884	6550	3832	—	—	—	—	Complete
Checks:														
(1)	—	—	934	6633	11097	13933	12867	9245	6168	8584	4183	4200	4600	Complete
(2)	—	—	794	4242	9133	11198	10492	8027	4345	—	—	—	—	Complete

[1] Low populations counted: high populations estimated.
[2] Commercial preparation.
[3] Prepared from nicotine sulfate solution and a commercial dust containing 14% of nicotine.
[4] Counts from one plot; other check plots discontinued.
[5] Trace.

The Mexican Leaf-Cutting Ant in the United States

L. F. BYARS, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

In March 1946 Jack Manthey and the writer found a nest of large leaf-cutting ants in the Organ Pipe Cactus National Monument, Arizona, and collected specimens, which have been determined by M. R. Smith as *Atta mexicana* (F. Smith). This species is similar in appearance, and presumably in habits, to *A. texana* (Buckley). According to Walter *et al.* (1938), the annual loss due to *A. texana* is estimated to average 6 dollars per nest. Other species of *Atta* are among the insects most destructive to agriculture in tropical and subtropical parts of the Americas.

Although small workers of *Atta texana* and *A. mexicana* are difficult to separate, the major workers (soldiers) may be distinguished by the following key:

Head and gaster opaque above, with numerous suberect hairs; a short spine on front of each occipital lobe of head, frontal furrow deep (Louisiana, Texas, northeastern Mexico) ..... *texana*

Head smooth, shining, nearly or quite hairless above; spines on front of head vestigial or absent, frontal furrow shallow; dorsal surface of gaster sub-opaque to shining, with spare erect hairs (Mexico, southern Arizona) .... *mexicana*

Atta mexicana (F. Smith) ?*Formica fervens* Drury, 1782, Illus. Nat. Hist. 3: 58, pl. 42, fig. 3. ♀. *Oecodoma mexicana* F. Smith, 1858, Cat. Hymen. Brit. Mus. 6: 185, pl. 10, fig. 20 ♀ : ♂.

One nest was found under a palo-de-hierro tree (*Olneya tesota*) near a gravel pit about 1 mile north of the Organ Pipe Cactus National Monument headquarters and about 5 miles north of the Mexican boundary. Other prominent plants in the vicinity were creosote bush (*Larrea tridentata*), mesquite (*Prosopis julifiora*), paloverde (*Cercidium* sp.), sahuaro (*Cereus giganteus*), and organpipe cactus (*Cereus thurberi*). In April 1948, R. E. Gregg and others collected large leaf-cutting ants (*Atta* sp.) from what may be another colony of *Atta mexicana* in the same locality. This is within the area inhabited by two Mexican species of cactus, the organpipe and the sinita (*Cereus schottii*), both of which are common in the State of Sonora, Mexico, but in the United States are limited to an area near and south of Ajo, Arizona. Much of this area is less than 2,000 feet above sea level.

On December 22, 1948, the writer found a thriving colony of *Atta mexicana* beside the highway near La Casita, Sonora, Mexico, 25 miles south of Nogales, Arizona, at an elevation of 3350 feet. The presence of this colony amid oak and mesquite trees indicates that this species can survive in many parts of southern Arizona which have similar vegetation and lower altitudes. Near Magdalena, Sonora, at an elevation of 2460 feet the writer saw citrus trees damaged by *A. mexicana*, although the species had not been reported previously at elevations above 2000 feet in northwestern Mexico.

Atta mexicana has been taken at Nogales, Arizona by members of the Division of Foreign Plant Quarantines, Bureau of Entomology and Plant Quarantine, with nursery stock and vegetables from Hermosillo and Etchojoa, Sonora, respectively. W. M. Wheeler listed the following localities for the species: Guadalajara, Jalisco (J. F. McClendon); Irapuato, Guanajuato (C. H. T. Townsend); Escuinapa, Nayarit (J. H. Batty); Cuernavaca, Morelos; Queretaro, Queretaro (W. M. Wheeler). M. R. Smith has sent the writer the following records:

U. S. National Museum Collection: Linares, Nuevo Leon (Phil Rau); Ciudad Victoria, Llera, and Santander Jimenez, Tamaulipas (V. E. Shelford); Jalapa, Vera Cruz (A. L. Herrara).

T. Pergande Collection: San Rafael, Vera Cruz (collector?), and Tepic, Nayarit (G. Eisen and F. H. Vaslit?).

W. M. Mann Collection: Tampico, Tamaulipas (Locke); Tuxpan, Vera Cruz ("A. Consul"). These localities range in altitude from the sea coast to an elevation of 5973 feet at Queretaro, and in area from the Organ Pipe Cactus National Monument on the north to Cuernavaca on the south.

Atta texana (Buckley) *Myrmica* (*Atta*) *texana* Buckley, 1860, Proc. Acad. Nat. Sci. Phila. 12: 233–236 ☿ ♀ ♂.

W. M. Wheeler showed by his figures of the genitalia of the males that this species is distinct from *Atta mexicana*.

According to M. R. Smith, *Atta texana* is found in approximately all of Texas south of the Oklahoma boundary and east of the 102° meridian, which passes near Lubbock, Midland, and Dryden. This ant is also found in thirteen parishes of western Louisiana, in an area bordered by Shreveport, Alexandria, and Lake Charles. Walter *et al.* (1938) mention this species from northeastern Mexico, but give no locality records.

Before 1940 carbon bisulfide was the only effective control known for *Atta texana* (Smith 1939) but methyl bromide has since been used (Johnston 1944). Alvin Grant, of Julius Hyman and Company, Denver, Colorado, has sent the writer news reports of tests conducted with chlordan in Texas and in Central America during the winter of 1947–48. These reports indicate that weak solutions of chlordan in large quantities may be the best control for leaf-cutting ants.

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A New Technique for Evaluating the Efficiency of Entomophagous Insects in the Field[1]

PAUL DEBACH,[2] E. J. DIETRICK,[3] and C. A. FLESCHNER,[4] *Division of Biological Control, University of California Citrus Experiment Station, Riverside*

In the course of field investigations designed to determine the efficacy of various natural enemies of the California red scale, *Aonidiella aurantii* (Mask.), it became highly desirable, because of nearly insurmountable difficulties encountered in acquiring accurate quantitative data, to have a supplemental experimental method of measuring the effectiveness of natural enemies, a simple method of determining changes in host populations in the presence and absence of parasites or predators.

Smith & DeBach (1942) used such a method in a field study of the effectiveness of *Metaphycus helvolus* (Compere) against the black scale on citrus. They state: "Briefly, the method consists of the excluding of parasites from hosts on certain branches of the host plant, while permitting them to have access to hosts on other branches in the immediate vicinity. By the use of organdy sleeves, . . . it is possible to accomplish this and thus to compare the survival of host populations on the same tree, in the presence and absence of the parasites."

Another method which attains the same results in a different manner is described by DeBach (1946), who states that "A simple check method which is the exact inverse of the ordinary untreated check used in insecticide evaluations is now available for measuring the efficacy of certain entomophagous insects. According to this method, a treated (poisoned) plot, instead of an untreated (unpoisoned) plot, is used as the check, the treatment of necessity being one which will eliminate or greatly reduce the entomophagous insects involved, while having little or no effect on the host population. Comparison of such a treated plot with a plot having the natural enemies normally present, or purposely introduced, will show by the difference in the two host populations just how valuable the parasites or predators are."

The sleeve method described above has a disadvantage in that the area of the host plant to be covered by the sleeves must first be freed of the host insect in order to eliminate parasites or predators, and must then be reinfested. This may cause a delay, and it is very likely to produce an experimental infestation differing in population density and developmental stages from the normal one on the rest of the tree.

The insecticidal check method may also have drawbacks. Certain writers (Osburn & Spencer 1938; Osborn & Mathis 1948; Holloway *et al.* 1942) have thought that residues from field-applied insecticides may possibly favor increase in host populations. Observed results, therefore, may not be due to the elimination of natural enemies. It is also possible that certain materials, such as DDT, may affect the physiology of the plant, which, in turn, may favor an increase of the host-insect population. The effect on the plant has been reported (Allen 1947) to be "a stimulation and suppression effect in some plants following treatments with DDT." To the present writers' knowledge, no associated effects on an insect population have yet been thoroughly demonstrated.

FIG. 1.—Closed, DDT-impregnated sleeve (left) and open, untreated sleeve (right) showing supporting rods. Sleeves are expanded by wire rings (front and rear) sewn in place at junctions of organdy strip and muslin end pieces.

In order to eliminate the objections noted above, a combination of the two methods has been devised. Organdy sleeves are used for exclusion of enemies as before, but the advantages of the insecticidal check method are added. The cloth of one sleeve of each pair used is impregnated with technical DDT by dipping it in a solution of DDT and allowing it to dry. The sleeve is then placed over a branch and is closed at both ends (Fig. 1, left, and Fig. 2). Inasmuch as the sleeve is so placed that the foliage does not touch the cloth, and the red scale is sessile on the foliage, neither the plant nor the insect host contacts the DDT. The active predators or parasites of the red scale eventually come into contact with the DDT-impregnated cloth of the closed sleeve, however, and are eliminated. The host-insect population then increases as it would in nature if it had no natural enemies. The other sleeve of each pair remains untreated and is left open at both ends to permit ingress and egress of parasites and predators (Fig. 1, right). A comparison of results in the paired sleeves gives a direct evaluation of the effectiveness of the natural enemies, especially when the entire

[1] Paper No. 596, University of California Citrus Experiment Station, Riverside, California.
[2] Assistant Entomologist in the Experiment Station.
[3] Principal Laboratory Technician in the Experiment Station.
[4] Junior Entomologist in the Experiment Station.

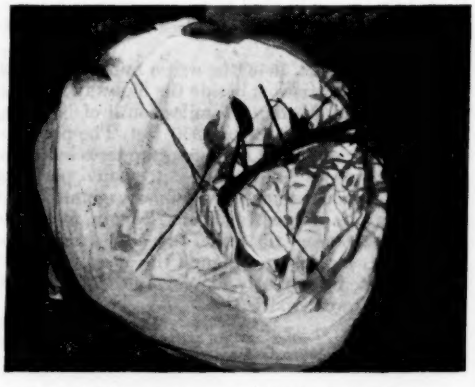

FIG. 2.—"Closed" sleeve folded back to show supporting frame of rear ring in place.

tree is used as a check against results in the open sleeve. Certain effects of the sleeves in altering the micro-climate can be minimized by proper placement of the sleeves with regard to the sun (Smith & DeBach 1942). Our observations thus far indicate that natural enemies of the California red scale, the citrus red mite, and the black scale work as usual under these conditions.

This method can of course be used only in a study of the effectiveness of the natural enemies of certain species of insects. Limitations of the method, not overcome by the improvements described in the present paper, have been discussed by Smith & DeBach (1942).

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Residual Action of Organic Insecticides Against Stable Flies

GAINES W. EDDY and W. S. MCGREGOR, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Some of the more valuable insecticides today are represented in the group of materials that retain their insecticidal properties for long periods after their application. The residual action of most of the materials included in this paper has been studied by other workers, but, so far as is known, no comparative tests have been made with all the materials against a single major insect pest. This paper presents the results obtained in laboratory tests on the speed of knock-down and of kill, and the duration of effectiveness of 11 of the more recently developed organic insecticides against the stable fly

METHODS.—Fourteen-mesh copper-wire screen cages, 3.5 inches in diameter and 8 inches high, were dipped in a 1 per cent solution of the test material in acetone. Two cages were dipped in each preparation. One was stored indoors while the duplicate was stored outdoors, exposed to the weather. Exposures were made near Kerrville, Texas, beginning May 14, 1948.

The treated cages were tested at a temperature of 80°±2F°. and a relative humidity of 50 to 70 per cent. Ten recently fed flies, 4 to 6 days old, were introduced into each cage. The flies were observed throughout the first 8 hours, and the time required for knock-down was noted. Further observations were made at 24 and 48 hours. Cages that failed to cause 100 per cent mortality of the flies in 48 hours were not tested further. All stored cages were tested simultaneously after exposures of 1, 7, 14, 50, and 126 days. The results are shown in table 1.

RESULTS.—*Speed of Knock-down.*—In the tests made 24 hours after the cages were treated, DDT and methoxychlor (methoxy analog of DDT) proved to be the fastest acting compounds and toxaphene and chlordan the slowest acting.

In subsequent tests the effectiveness of the materials was in general reflected in the time required for complete knock-down of the flies.

Duration of Effectiveness and Speed of Kill.—In tests made after 7 days, the cage treated with methoxychlor and exposed outdoors showed no apparent deterioration, whereas the DDT-treated cage exposed outdoors required much longer to cause knock-down than did the cage stored indoors. Cages treated with gamma benzene hexachloride and parathion and exposed to outdoor conditions proved less effective than cages that had been held inside.

A decrease in speed of kill was noted with all cages in the tests made after 14 days, except for the two treated with methoxychlor and the one treated with DDT and held indoors. All the materials, however, caused 100 per cent mortality within 48 hours.

All but two of the treatments exposed to outdoor conditions failed in the tests made after 50 days. The effective materials were methoxychlor and the bromine analog of DDT (2,2-bis(*p*-bromophenyl)-1,1,1-trichloroethane). Although they did not withstand the outdoor exposure, cages treated with DDT, parathion, compound 118 (1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4,5,8-dimethanonaphthalene), and toxaphene remained effective after 50 days of indoor storage.

After 126 days the cage treated with the bromine analog of DDT and held outdoors was no longer effective. Of the cages held indoors, only those treated with DDT and its bromine analog remained effective. The cages treated with methoxychlor were cleaned through error; therefore, no further data could be obtained.

Both methoxychlor and the bromine analog of DDT appeared to be more persistent than DDT when exposed to the weather. Of the compounds related to chlordan, compound 118 appeared to be the most persistent. Very little has been published concerning the efficacy of the bromine analog of DDT as an insecticide. From the results obtained it appears that this material warrants further testing.

Although the results described above represent only single treatments, the findings are in line with those obtained in similar experiments conducted against other species of flies at Kerrville.

SUMMARY.—The speed of knock-down and of kill, and the duration of effectiveness of 11 of the more recently developed organic insecticides were studied in laboratory tests against the stable fly, *Stomoxys calcitrans* (L.). Two 14-mesh copper-wire cages were dipped in a 1 per cent solution of each test material in acetone. One cage was held indoors while its duplicate was stored outdoors, fully exposed to the effects of the weather.

In the tests made 24 hours after the cages were

Table 1.—Knock-down and kill[1] of stable flies held inside screen-wire cages treated with 11 organic insecticides.

Insecticide	Time Required to Cause 100 Per Cent Knock-Down	
	Cages Stored Indoors	Cages Stored Outdoors
	Tests made after 24 hours	
DDT	8 min.	
Methoxychlor	13 min.	
Bromine analog of DDT	22 min.	
Parathion	24 min.	
Dichlorodiphenyl dichloroethane	25 min.	
Gamma benzene hexachloride (95%)	26 min.	
Compound 118	70 min.	
Compound 153[2]	80 min.	
Heptachlor	113 min.	
Toxaphene	125 min.	
Chlordan	130 min.	
	Tests made after 7 days	
DDT	11 min.	8 min.
Methoxychlor	12 min.	13 min.
Bromine analog of DDT	—	—
Parathion	320 min.	8–24 hr.
Dichlorodiphenyl dichloroethane	330 min.	310 min.
γ Benzene hexachloride	350 min.	8–24 hr.
Compound 118	8–24 hr.	24–48 hr.
Compound 153	24–48 hr.	24–48 hr.
Heptachlor	24–48 hr.	24–48 hr.
Toxaphene	8–24 hr.	8–24 hr.
Chlordan	8–24 hr.	8–24 hr.
	Tests made after 14 days	
DDT	14 min.	110 min.
Methoxychlor	11 min.	12 min.
Bromine analog of DDT	67 min.	67 min.
Parathion	8–24 hr.	8–24 hr.
Dichlorodiphenyl dichloroethane	448 min.	315 min.
γ Benzene hexachloride	461 min.	8–24 hr.
Compound 118	24–48 hr.	24–48 hr.
Compound 153	24–48 hr.	24–48 hr.
Heptachlor	24–48 hr.	24–48 hr.
Toxaphene	8–24 hr.	8–24 hr.
Chlordan	24–48 hr.	24–48 hr.
	Tests made after 50 days	
DDT	25 min.	Cage ineffective
Methoxychlor	18 min.	14 min.
Bromine analog of DDT	370 min.	368 min.
Parathion	8–24 hr.	Cage ineffective
Dichlorodiphenyl dichloroethane	Cage ineffective	Cage ineffective
γ Benzene hexachloride	Cage ineffective	Cage ineffective
Compound 118	8–24 hr.	Cage ineffective
Compound 153	Cage ineffective	Cage ineffective
Heptachlor	Cage ineffective	Cage ineffective
Toxaphene	24–48 hr.	Cage ineffective
Chlordan	Cage ineffective	Cage ineffective
	Tests made after 126 days	
DDT	312 min.	
Bromine analog of DDT	8–24 hr.	Cage ineffective
Parathion	Cage ineffective	
Compound 118	Cage ineffective	
Toxaphene	Cage ineffective	
Methoxychlor	(Cages lost—cleaned through error)	

[1] All treatments caused 100 per cent mortality within 24 or 48 hours, except those designated as ineffective.
[2] Composition of compound not disclosed by manufacturer.

treated, DDT and methoxychlor proved to be the fastest acting compounds and toxaphene and chlordan the slowest acting.

From the standpoint of knock-down and duration of effectiveness, methoxychlor and the bromine analog of DDT appeared to be superior to any of the other nine compounds tested, including DDT. Parathion, compound 118, and toxaphene appeared to retain their toxic properties longer than did dichlorodiphenyl dichloroethane, gamma benzene hexachloride (95%), compound 153, heptachlor, or chlordan.

Insecticidal Tests of Plants from Tropical America

A. F. SIEVERS,[1] W. ANDREW ARCHER,[1] RUFUS H. MOORE,[2] and E. R. MCGOVRAN[3]

When it was first generally recognized that the poisonous spray residues on fruits and vegetables constitute a serious menace to public health a widespread search began for highly efficient nonpoisonous insecticides. The successful use of rotenone, constituent of several species of tropical fish poison plants, as a commereial insecticide suggested the possibility that other plants in the tropics used as fish poisons or for purposes indicating the presence of physiologically active constituents might be equally useful. To explore the possibilities in this field a cooperative investigation was undertaken by several agencies of the U. S. Department of Agriculture.

The Division of Plant Exploration and Introduction, Bureau of Plant Industry, Soils, and Agricultural Engineering, sent a botanist on a year's search for such plants in northern South America to collect seed and other planting stock for propagating the species. The collection trip in Venezuela, Colombia and the British, Dutch, and French Guianas required about 11 months, July 5, 1934 to May 30, 1935. All collections were sent to Washington and the seeds and cuttings propagated at the Glenn Dale Station of that division. Seed and young plants thus obtained were shipped to the Puerto Rico Agricultural Experiment Station of the Office of Experiment Stations, Mayaguez, Puerto Rico, for cultivation.

MATERIALS AND METHODS.—For several years material representing dried roots, stems, leaves, flowers, and seed of the species under cultivation supplemented by similar material collected from related species in Puerto Rico was prepared in the Division of Drug and Related Plants of the Bureau of Plant Industry, Soils, and Agricultural Engineering, for testing in the Division of Control Investigations, Bureau of Entomology and Plant Quarantine, to determine their toxicity to insects. The preparations included finely ground samples and alcohol, acetone and petroleum ether extracts of the several plant parts in most cases.

Three types of tests were used: The turntable method (Campbell & Sullivan, 1938) using houseflies, *Musca domestica* L.; the dusted leaf section method (Swingle *et al.*, 1941) using leaf-eating larvae; and a method using mosquito larvae. In the last method named, 0.3 ml. of the plant extract were added to 100 ml. of distilled water containing 50 fourth instar *Culex* mosquito larvae. The following species of larvae were used in the dusted leaf section tests: Beam leaf roller, *Urbanus proteus* (L.); cabbage looper, *Trichoplusia ni* (Hbn.); celery leaf tier, *Phlyctaenia rubigalis* (Guen.); Colorado potato beetle, *Leptinotarsa decemlineata* (Say); cross-striped cabbageworm, *Evergestis rimosalis* (Guen.); diamond back moth, *Plutella maculipennis* (Curt.); Hawaiian beet webworm, *Hymenia recurvalis* (F.); imported cabbageworm, *Pieris rapae* (L.); melonworm, *Diaphania hyalinata* (L.); southern armyworm, *Prodenia eridania* (Cram.); southern beet webworm, *Pachyzancla bipunctalis* (F.); yellow woollybear, *Diacrisia virgnica* (F.); and *Noropsis hieroglyphica* Cramer (no accepted common name.)

RESULTS.—Of the materials from the 78 species of plants tested, all of the parts of *Cnidoscolus urens*, *Gliricidia sepium*, *Hura crepitans*, *Mammea americana*, and *Piscidia piscipula* tested showed appreciable insecticidal action and the results are listed in table 1. *Mammea americana* ranked highest as an insecticide, as all the parts tested showed considerable toxicity.

The other plants tested are given in lists 1 and 2. List 1 gives the 30 species that showed toxicity to one or more species of insects in some but not all of the parts tested. The 43 species that were non-toxic or only very slightly toxic to insects in all the parts tested are given in list 2.

DISCUSSION.—In general, higher mortalities were obtained with mosquito larvae than with any other species of insect. Ninety per cent or more of these larvae were killed by at least one of the extracts of seed or fruit of *Gliricidia sepium*, *Hura crepitans*, *Mammea americana*, *Calopogonium coeruleum*, *Clibadium erosum*, *Piper tuberculatum*, and *Sapindus saponaria*. Leaves of *Mammea americana*, *Cassia alata*, *Cassia spectabilis*, and *Solanum mammosum* caused mosquito larval mortalities of this same order.

The leaf-feeding larvae were generally resistant to the plant materials. However, *Piscidia piscipula* which is positive to the Durham test, killed 50 per cent or more of four species and *Cnidoscolus urens* and *Gliricidia sepium* were equally effective against two species as shown in table 1. Roots of *Spigelia anthelmia* killed over 75 per cent of the larvae of two species.

It seems doubtful that any of the materials tested could successfully compete with commercial insecticides now in use in the United States. However, as a source of material from which new insecticidal toxicants might be isolated and identified, these data show some definite leads.

SUMMARY.—Tests were made of the insecticidal properties of 78 species of plants used as fish poisons, insecticides, or drugs, mainly in Venezuela, Colombia, the Guianas, and Puerto Rico. Seed and other propagating stock were collected in these regions and assembled for the cultivation of the species at the Agricultural Experiment Station at Mayaguez, P. R., to furnish material for the tests. Powders of the several plant parts of each species and extracts of such parts with organic solvents were tested for toxic action to insects. All of the plant parts of *Mammea americana*, *Cnidoscolus urens*, *Gliricidia sepium*, *Hura crepitans*, and *Piscidia piscipula* tested had insecticidal action against some of the 15 species of insects used in the tests. Since the toxicants were not identified some of the toxic plants may contain new insecticidal constituents of possible commercial value. Thirty other species of plants were toxic to some degree.

List 1.—Plants which possessed toxicity to insects in some but not all of the parts tested

Aeschynomene sensitiva Sw.
Albizzia lebbeck (L.) Benth.
Ambrosia cumanensis H. B. K.

[1] Division of Tobacco, Medicinal, and Special Crops, and Division of Plant Exploration and Introduction, respectively, Bureau of Plant Industry, Soils, and Agricultural Engineering. Agr. Res. Adm. U.S.D.A.

[2] Formerly with the Puerto Rico Agricultural Experiment Station, Mayaguez, P.R., of the Office of Experiment Stations. Agr. Res. Adm., U.S.D.A.

[3] Formerly with the Division of Control Investigations, Bureau of Entomology and Plant Quarantine; Agr. Res. Adm., U.S.D.A. Credit is due J. W. Kelly for making the plant extracts and M. C. Swingle, W. N. Sullivan, and associates for conducting the biological tests.

Table 1.—Results of tests of plants showing insecticidal action in all parts tested.

Plant and Habitat	Part Tested	Results with Dusts		Results with Extracts					
				Acetone		Alcohol		Petroleum ether	
		Insect[1]	Mortality	Insect[1]	Mortality	Insect[1]	Mortality	Insect[1]	Mortality
			Per cent		*Per cent*		*Per cent*		*Per cent*
Cnidescolus urens (L.) Arthur	Green fruit	1	0	—		—		—	
Small shrub, 3–5 feet,		2	11	—		—		—	
Tropical America		3	100	—		—		—	
		4	93	—		—		—	
		5	33	—		—		—	
	Leaves	1	4	6	86	6	0	6	0
	Roots	1	0	6	38	6	0	6	0
	Stems	1	4	6	49	6	0	6	0
Gliricidia sepium (Jacq.) Steud.	Flower clusters	1	29	—		—		—	
Small tree, 30 feet,		7	0	8	22	8	0	8	80
Tropical America	Green fruit	1	99	8	0	8	0	—	
		7	0	—		—		—	
		9	0	—		—		—	
		10	32	—		—		—	
		1	13	—		—		—	
		11	16	—		—		—	
	Ripe fruit	1	59	8	0	8	0	8	94
		7	3	—		—		6	0
	Leaves	1	55	8	0	8	0	8	36
		7	12	—		—		—	
		5	50	—		—		—	
		1	0	—		—		—	
		2	0	—		—		—	
		4	11	—		—		—	
		3	0	—		—		—	
	Roots	7	29	8	0	8	0	8	50
		1	6	—		—		—	
		5	63	—		—		—	
		2	0	—		—		—	
		4	6	—		—		—	
		3	6	—		—		—	
	Stems	1	37	8	0	8	0	8	14
Hura crepitans L.	Green fruit	1	0	8	100	8	0	8	100
Tree, 30–40 feet,		—		6	0	6	0	6	0
Tropical America	Ripe fruit	7	26	8	0	8	0	8	60
	(minus seed)	1	2					6	0
	Leaves	1	0	8	0	8	0	8	27
		7	13	—		—		—	
	Roots	7	0	8	0	8	0	8	44
		1	0	—		—		—	
	Ripe seed	—		8	18	8	0	8	100
		—		6	0	6	0	6	0
	Stems	1	33	—		—		—	
		7	0	—		—		—	
		12	12	—		—		—	
Mammea americana L.	Green fruit	1	0	8	84	8	60	8	96
Tree, 30–60 feet,		—		6	28	6	20	6	40
Tropical America	Ripe fruit	1	0	6	14	6	14	6	12
		11	0	8	68	8	75	8	72
	Leaves	1	0	8	44	8	32	8	96
		11	16	—		—		6	25
		13	0	—		—		—	
	Roots	1	2	8	32	8	24	8	94
		—		—		—		6	45
		11	1	—		—		—	
		13	0	—		—		—	
	Ripe seed	1	19	8	94	8	92	6	45
		11	26	6	30	6	25	—	
		10	100	—		—		8	90
	Stems	1	0	8	0	8	0	8	92
		—		—		—		6	11
		11	0	—		—		—	
		13	0	—		—		—	
Piscidia piscipula (L.) Sarg.	Leaves	1	0	—		—		—	
Tree, 15–30 feet,		2	2	—		—		—	
Tropical America		3	75	—		—		—	
		4	90	—		—		—	
		5	7	—		—		—	
	Roots	1	0	—		—		—	
		2	50	—		—		—	
		3	25	—		—		—	
		4	44	—		—		—	
		5	57	—		—		—	
	Stems	1	0	—		—		—	
		2	0	—		—		—	
		3	0	—		—		—	
		4	35	—		—		—	
		5	0	—		—		—	

[1] The numbers indicate the test insect: (1) Southern armyworm, (2) Melonworm, (3) Hawaiian beet webworm, (4) Southern beet webworm, (5) Yellow woollybear, (6) Housefly, (7) Cabbage looper, (8) Mosquito, (9) *Noropsis hieroglyphia*, (10) Imported cabbageworm, (11) Cross-striped cabbageworm, (12) Bean leaf roller, (13) Celery leaf tier.

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Benthamantha caribaea (Jacq.) Kuntze
Bontia daphnoides L.
Calea glomerata Klatt
Calopogonium coeruleum (Benth.) Sauv.
Calopogonium mucunoides Desv.
Calotropis gigantea (L.) Dry.
Cassia alata L.
Cassia hirsuta L.
Cassia spectabilis DC.
Chenopodium ambrosioides L.
Cleome spinosa Jacq.
Cleome psoraleoaefolia DC.
Clibadium erosum (Sw.) DC.
Clibadium surinamense L.
Datura candida (Pers.) Safford
Indigofera suffruticosa Mill.
Jacaranda filicifolia (Anders.) Don
Jatropha curcas L.
Jatropha gossypifolia L.
Paullinia fuscescens H. B. K.
Petiveria alliacea L.
Phyllanthus acuminatus Vahl.
Piper tuberculatum Jacq.
Sapindus saponaria L.
Solanum mammosum L.
Spigelia anthelmia L.
Tetrapteris acutifolia Cav.

List 2.—Plants that were non-toxic to insects

Aeschynomene americana L.
Albizzia falcata (L.) Baker
Albizzia mollis Boiv.
Andira inermis (Sw.) H. B. K.
Banisteriopsis caapi (Spruce) Morton
Brysonima crassifolia (L.) DC.
Calliandra marginata Griseb.
Canavalia macropleura Piper
Cardiospermum grandiflorum Sw.
Cassia occidentalis L.
Centrosema plumieri (Turp.) Benth.
Centrosema pubescens Benth.
Cestrum latifolium var. *tenuiflorum* (H. B. K.) O. E. Schulz
Cleome pruriens Tr. & Pl.
Clitoria arborea Benth.
Clitoria rubiginosa Juss.
Coccinia cordifolia (L.) Cogn.
Crotalaria incana L.
Dalea carthaginensis (Jacq.) Macbr.
Desmanthus virgatus (L.) Willd.
Dieffenbachia seguine (L.) Schott
Dioclea macrantha Huber
Dioclea sericea H. B. K.
Dioscorea polygonoides Humb. & Bonpl.
Eugenia atropunctata Steud.
Eupatorium odoratum L.
Euphorbia lancifolia Schlecht.
Furcraea foetida (L.) Haw.
Furcraea tuberosa (Mill.) Ait.
Jatropha podagrica Hook.
Nissolia fruticosa Jacq.
Phaseolus lathyroides L.
Phyllanthus niruri L.
Piper geniculatum Sw.
Polygonum punctatum Ell.
Ruprechtia coriacea (Karst.) Blake
Scoparia dulcis L.
Serjania glabrata H. B. K.
Serjania paucidentata DC.
Serjania rhombea Radlk.
Sesbania sericea (Willd.) Link
Solanum leucocarpon Dun.
Stizolobium pruriens (Stickm.) Medic

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Comparison of Calcium Arsenates Alone and Mixed with Organic Insecticides for Cotton Insect Control[1]

J. S. ROUSSEL and J. C. GAINES, *Texas Agricultural Experiment Station, College Station*

Since the discovery of calcium arsenate, it has been used as a control for the cotton boll weevil, *Anthonomus grandis* Boh. One of its imperfections is the increased cotton aphid, *Aphis gossippii* Glov., infestation following repeated applications. Entomologists have recommended the use of nicotine sulphate in combination with calcium arsenate to prevent aphid increases, but due to the scarcity of nicotine and its deterioration in storage, when mixed with calcium arsenate, planters have been reluctant to follow this procedure. Nicotine sulphate mixed with calcium arsenate has been found effective as a "knock out" for aphid infestations provided the dust is applied under proper weather conditions.

Considerable research has been conducted by entomologists comparing the toxicity of calcium arsenate containing different percentages of water soluble arsenic and a different particle size. A so-called "neutral" calcium arsenate (pH. 9.80) was used in tests by Gaines (1944). In this experiment the "neutral" calcium arsenate gave better control of the bollworm and higher yields than commercial calcium arsenate. It was found that the aphid infestations were higher on the "neutral" calcium arsenate treated plats than on those treated with commercial calcium arsenate. Mixtures of rotenone and calcium arsenates have also been studied, but they have not proven entirely satisfactory in aphid prevention.

Benzene hexachloride has been mixed with commercial calcium arsenate and used in tests by various entomologists. Becnel *et al.* (1947), Rainwater & Bondy (1947) and Gaines & Young (1948) reported that benzene hexachloride and commercial calcium arsenate were incompatible. Dunnam & Calhoun (1948) found some calcium arsenates that were compatible with benzene hexachloride. Ewing *et al.* (1947) reported that a special calcium arsenate (lime free) mixed with benzene hexachloride was effective against cotton aphids, boll weevils and bollworms in laboratory tests. Benzene hexachloride and parathion, each mixed with a special calcium arsenate (lime free), proved effective against boll weevils in field tests by Gaines & Dean (1949).

The work herein reported was conducted in the laboratory at College Station. Its purpose was to determine the comparative effectiveness of a special

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calcium arsenate and commercial calcium arsenate alone and in combination with organic insecticides when used against boll weevils and cotton aphids. The special calcium arsenate contained 33.2 per cent total arsenic, 6.7 per cent water soluble arsenic, pH. 6.9 and contained no free lime. The commercial calcium arsenate contained 28.1 per cent total arsenic, 0.14 per cent water soluble arsenic and 16.8 per cent free lime.

The dusting chamber, guns, air pumps, and cages used in these cage tests against boll weevil were similar to those used and described by Gaines & Dean (1949). Weevils collected from the field were used in the tests. The average daily temperatures during the test period ranged from 84 to 92° F. and the average daily relative humidity ranged from 44 to 63 per cent.

Abbott's formula was used to calculate the percentage control. The dosages were calculated to an acre-basis and changed to logarithms and the percentage mortalities were changed to probits for calculating the dosage-mortality curves. The regression lines were calculated according to Bliss' (1938) method.

The results of the boll weevil toxicity tests are shown in figure 1. The MLD for commercial calcium arsenate was 5.07 pounds per acre as compared to 4.95 pounds per acre for the special calcium arsenate. The slope of the line for commercial calcium arsenate was slightly steeper, having a regression coefficient of 1.96, than for the special calcium arsenate with a regression coefficient of 1.27.

Fresh mixtures of special calcium arsenate—0.5 per cent gamma benzene hexachloride and special

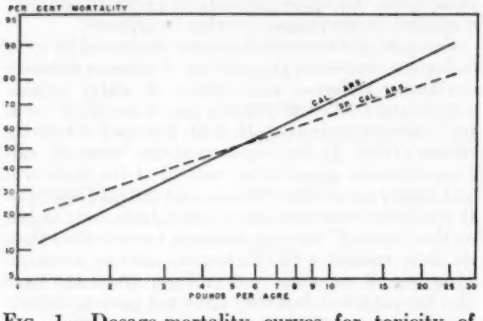

FIG. 1.—Dosage-mortality curves for toxicity of calcium arsenates indicated to field-collected weevils.

calcium arsenate—0.1 per cent parathion were tested against cotton aphids. Aphid infested leaves collected from plants in the field were used in these tests. The infested leaves were examined for live aphids and the numbers recorded. The leaf samples were then placed in a dusting tower to be dusted with the insecticides at varying dosages, herein expressed as pounds per acre. Weighed glass slides were placed in the tower to determine the exact dose after allowing the dust to settle for 30 seconds. After dusting, the infested leaves were immediately removed from the dusting chamber and each leaf petiole was placed in a vial containing water fastened within a small cylindrical dish to catch all falling aphids. These dishes were placed in a cabinet at a constant temperature of 85° F. and 70 per cent relative humidity for a 24 hour period. At the end of this time the numbers of live aphids were recorded and the percentage control calculated.

In these aphid toxicity tests shown in figure 2, the mixture of special calcium arsenate—0.1 per cent parathion was decidedly more effective than the special calcium arsenate—0.5 per cent gamma benzene hexachloride. The MLD for the special calcium arsenate—0.1 per cent parathion mixture was 2.97 lbs. per acre, with a regression coefficient of 3.44 as

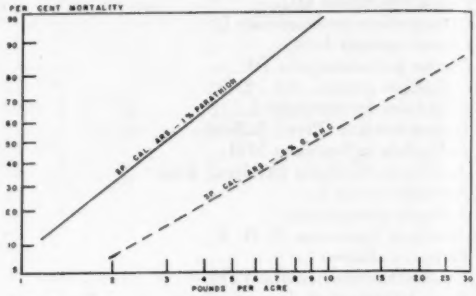

FIG. 2.—Dosage-mortality curves for the toxicity of insecticides indicated to cotton aphids.

compared to a MLD of 9.33 lbs. per acre for the special calcium arsenate—0.5 per cent gamma benzene hexachloride with a regression coefficient of 2.05.

SUMMARY.—In cage tests, commercial calcium arsenate and special calcium arsenate were equally effective in their toxicity to the boll weevil.

In the cotton aphid tests, a fresh mixture of special calcium arsenate—0.1 per cent parathion had a much lower LMD than the special calcium arsenate—0.5 per cent gamma benzene hexachloride.

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Silica Aerogel for Protecting Stored Seed or Milled Cereal Products from Insects

R. T. COTTON and J. C. FRANKENFELD, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine, Manhattan, Kansas*

In recent years much has been published regarding the effectiveness of silica dusts mixed with grain and seed to protect them from insect attack. These dusts cause the death of insects by abrading the waxy coating of their cuticle, thus destroying its impermeability and promoting the rapid loss of body moisture. Insects that live in stored grain and similar dry food materials depend upon their food supply for their moisture needs. When feeding in grains or milled cereals that contain only the normal percentage of moisture, insects cannot readily replace water lost as a result of abrasion by dusts, and death by desiccation quickly follows. Experiments conducted by the writers with a finely divided silica, known as silica aerogel, indicate this material to be more effective against the insect pests of stored grain and milled cereal products than any other form of silica tested.

The original source of the silica is sodium silicate. In the manufacture of the aerogel the liquid phase of the gel form is removed without otherwise altering the structure. Air replaces the liquid which was present when the gel was made. This process results in a dry, light particle having the same volume as the original gel. Unlike ordinary silica gel, the aerogel is not hygroscopic.

The typical chemical analysis of this material is as follows: SiO, 89.5 to 91.5 per cent; volatile (water, alcohol, and acetaldehyde), 5 to 6 per cent; sodium sulfate, 2.5 to 3.5 per cent; aluminum oxide plus ferric oxide, 1 per cent; pH (2.5 grams suspended in 100 cc. of water), 3.5 to 4 per cent.

The physical properties are as follows: color, white; dry bulk density, approximately 6 pounds per cubic foot; absolute density, 127.9 pounds per cubic foot; specific gravity, 2.2; oil absorption, too high for conventional test methods; index of refraction, 1.464; average particle diameter, 3 to 5 microns.

The effectiveness of silica aerogel in protecting seed wheat and various types of milled-cereal products was tested by confining adults of the confused flour beetle *Tribolium confusum* Duv., the rice weevil *Sitophilus oryza* (L.), or the granary weevil *S. granarius* (L.), and larvae of the confused flour beetle and the Mediterranean flour moth *Ephestia kühniella* Zell., in samples of wheat or feed ranging from 50 to 500 grams treated with various dosages of the dust. Results obtained in this series of tests indicate that the minimum effective dosages for various materials are as follows:

Material	*Silica Aerogel, Per Cent by Weight*
Seed wheat of 12 per cent moisture content	0.025
Seed wheat of 14 per cent moisture content	0.05
Feed in pellet form	0.025
Feed, Ground	0.5
Bird food (mixture of seeds and finely ground feed)	1.0
Powdered hand soap (60 per cent cornmeal)	0.05

One treatment with silica aerogel should afford protection to feed or seed from insect damage for an indefinite period. It was observed that heavy treatments caused 100 per cent mortality of insects in 1 to 2 weeks, whereas marginal dosages required 5 or 6 weeks to give a complete kill of insects introduced into the treated samples.

Preliminary tests indicate that light applications of silica aerogel to the surface of wheat in farm storage bins may be useful in preventing infestation by incoming insects. Its use throughout the bulk of grain to protect it against weevil damage is not recommended, since grain so treated would be classified under the official standards of the United States as treated, and graded "limed," and hence subject to discount. Although cleaning operations will remove much of the excess dust, enough will cling to the bran coat of wheat kernels to make its presence evident to the touch.

To test its oral toxicity, the manufacturers of silica aerogel report that in the course of feeding experiments a suspension of silica aerogel in water (100 grams per liter, total volume) was prepared and administered to guinea pigs. Each guinea pig received 2 milliliters of the suspension or 200 milligrams of dust, 6 days a week for 2 months. The conclusions of the pathologist making the tests were as follows:

"The daily ingestion by guinea pigs of 200 milligrams of the material fails to affect the growth and does not produce the pathological lesions which would be expected if the material were absorbed."

No experiments have been conducted to determine its effect on the palatability of treated grains and mill feeds.

The dust is highly irritating when breathed. Therefore, if products are treated with silica aerogel, workmen should be protected from breathing the dust by the use of suitable respirators and by proper ventilation.

With reference to the possible silicosis hazard from breathing the dust, the manufacturers have issued the following statement:

"Unpublished work at a reliable institution showed no evidence of acute toxicity after inhalation of the powder in concentrations as high as 60 milligrams per cubic foot of air. This concentration is much higher than found in any industrial application. The interpretation of these figures is that silica aerogel possesses negligible acute toxicity.

"Clinical and x-ray studies in workers exposed to silica aerogel during manufacture for the past five years as well as preliminary animal experimentation show no evidence of a silicosis producing property. Silica aerogels as a rule are not capable of producing nodular fibrosis of a silicotic type.

"However it is recommended that dusting be kept to a minimum by proper ventilation and that workers exposed to continuous dust wear satisfactory respirators."

Field Tests with New Insecticides for Control of the Alfalfa Weevil[1]

ELLSWORTH HASTINGS and J. H. PEPPER, *Montana State College, Agricultural Experiment Station, Bozeman*

During the past decade the alfalfa weevil, *Hypera postica* Gyll., appears to have become established in Montana and is now a major pest of alfalfa in the south-central counties of the state. In some sections within the above area damage from the weevil has been so serious that farmers have been forced to delete alfalfa plantings from their normal crop rotations.

The reluctance on the part of farmers to use arsenicals for the control of this pest, and the poor results obtained from the dusting and spraying of stubble with the new organic insecticides after the first cutting of alfalfa has been removed, has led to an attempt to find a more effective means of control for this insect.

A series of tests involving a pre-season treatment of infested plots to control the over-wintering adults before egg laying had commenced was instituted by this station in the spring of 1948. A field was selected in an area which had previously experienced extensive weevil damage to alfalfa plantings. The planting was 3 years old, comparatively free from grass and weeds and was one-fourth mile from the nearest neighboring alfalfa field. The test field was divided into four, approximately 4-acre "lands," by parallel irrigation ditches. Three of the "lands" were utilized as treated plots, the fourth serving as a check. No quantitative data were obtained as to the uniformity of infestation throughout the plots, but it was determined that weevils were present in all parts of the field.

In addition to the alfalfa weevil, the following weevil species, in varying numbers, were also found in collections made from the plots: *Hypera nigrirostris* F., *Sitona cylindricollis* F., *Sitona hispidula* F., *Brachyrhinus ovatus* L., *Ceutorhynchus punctiger* Gyll.[2]

Emulsion concentrates of DDT, chlordan, and toxaphene were applied as sprays at the rate of 2 pounds of the technically pure toxic ingredient per acre. A single application of the sprays was made on April 20, 1948, at which time the new growth of alfalfa was 1 to 1.5 inches high. The materials were applied at 50 pounds pressure. The day was clear and bright with the air temperatures in the middle sixties.

Table 1.—Adult weevil mortality at the various times with the respective treatments.

Time	Insecticide	Total Weevils in the Sample	Per Cent Mortality
24 hrs.	DDT	31	63
24 hrs.	Chlordan	32	45
24 hrs.	Toxaphene	25	68
48 hrs.	DDT	6	50
48 hrs.	Chlordan	12	59
48 hrs.	Toxaphene	10	50
14 days	DDT	20	95
14 days	Chlordan	13	100
14 days	Toxaphene	13	92

The plots were sampled 24 and 48 hours after the spray application and again at the end of 14 days. The sampling was done by cutting alfalfa crowns one-half inch below the soil surface and examining the material for dead and alive weevils. The results of this sampling are tabulated in table 1.

In addition to sampling for dead and living weevils several hundred alfalfa shoots and stems were collected from the various plots for examination of egg deposition. These random samples were collected on the day the sprays were applied and again 14 and 28 days later. No egg deposits were found to be present on the day the sprays were applied. The results of the 14 and 28 day counts are tabulated in table 2. Sweeps, using a standard insect net, were also made 24 days after treatment. The number of adult weevils per 100 sweeps on the various plots is also recorded in table 2.

Table 2.—The per cent of the alfalfa stems found to contain weevil egg deposits at 14 and 24 days after treatment and the number of adult weevils per 100 sweeps obtained from the plots 24 days after spraying.

Time, Days	Plot	Stems Inspected	Per Cent Containing Eggs	Weevils per 100 Sweeps
14	Check	46	54.0	—
14	Toxaphene	66	1.5	—
14	Chlordan	91	1.1	—
14	DDT	58	1.7	—
24	Check	107	42.1	72
24	Toxaphene	100	4.0	38
24	Chlordan	81	0.0	4
24	DDT	83	9.6	21

In all of the stems checked, the number of weevil eggs per puncture varied from a single egg to as many as 11 per puncture. Most punctures contained three or more eggs and many stems were found to contain two or three punctures per stem.

Another inspection of the plots was made 39 days after they were treated, at which time hatching of the eggs was in progress. Sweep samples were taken from the various plots and the adult weevils counted. The results of this examination are presented in table 3.

[1] Published as Scientific Paper No. 216, Montana State College, Agricultural Experiment Station.

[2] These species were identified by the Division of Insect Identification, Bureau of Entomology and Plant Quarantine, Washington, D. C.

Table 3.—Results of the inspection for adult weevils made 39 days after treatment.

Plot	Number of Adult Weevils per 100 Sweeps
Check	191
DDT	56
Toxaphene	92
Chlordan	26

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Examination at the time of harvesting the first cutting showed a marked difference between the treated and check plots in the amount of destruction to the alfalfa foliage.

The foliage on the treated plots was a healthy green color whereas the untreated alfalfa showed the white color usually associated with the feeding of large numbers of alfalfa weevil larvae.

The difference in the amount of damage to these plots was most strikingly demonstrated in the observations made a week after the first cutting was harvested. In this area, in heavily infested fields, the start of new growth following the first cutting is usually retarded from 1 to 2 weeks due to the excessive feeding of weevil larvae on the new shoots. This situation was observed on the check plot in which there was no new growth at all, and to some extent on the plots treated with DDT and toxaphene. In the plot treated with chlordan, no retardation in the new growth or vigor was noted.

The results obtained from the above experiments make it appear that heavy losses to alfalfa growers may be largely averted by the proper application and proper timing of a chlordan spray program designed to destroy the adult weevils before appreciable egg laying has commenced. The necessity of accurately timing the spray cannot be overemphasized, as it is apparent that once egg deposition has progressed to any extent the value of this type of control would be greatly diminished.

Bermuda Grass Seed Insects in Arizona

J. N. RONEY, *University of Arizona, Agr. Extension Service, Phoenix*

Over nine-tenths of the Bermuda grass seed of the world is produced in Yuma County, Arizona, under irrigation. The grass produces about 2,000,000 pounds of seed each year. For many years alfalfa and Bermuda were grown as companion crops. The irrigation water in parts of this county has a high salt content, and the Bermuda grass was allowed to creep in as a soil reclaimer.

Since the war many growers have planted entire fields to Bermuda grass. Two crops of seed are harvested yearly—one in June and one in November. The first crop usually gives the better yields as it has a longer growing period. The yields will range from 300 to 800 pounds for the first crop and 300 to 450 pounds for the second crop.

Prior to 1947 Bermuda grass seed could be produced with only the addition of some fertilizers. There were no insect pests or diseases to worry about. In fact, most people consider the grass a menace and are interested in getting rid of it. But this is not the case in Yuma County, Arizona, for they want it to grow for the seed.

Early in November, 1947, several samples of Bermuda grass infested with a white fly (not yet identified) were sent to the writer. It was reported that this insect was the cause of a very low yield of seed this year. Examinations showed many aleroydids present; however, there was no apparent damage to the stems or blades as the stems were joined together for over 2 feet in length in most cases. During the winter of 1947–48, several fields of Bermuda started to die. Examinations were made by the Extension Entomologist and the county agent, and we found the crowns and many nodes heavily infested with the scale insect *Odanaspis ruthae*. This scale had been seen before on Bermuda grass by the writer in Mississippi and Texas; however, it was only in spots and not serious. Control measures for this scale are planned for the winter of 1948–49 in fields where the insect was not controlled by the parathion dusts applied for insects discussed in the following paragraph.

During June, 1948, County Agent Young, of Yuma and the Extension Entomologist, spent a half day examining Bermuda plants in bloom. When we were about ready to give up, we located some plants in the boot stage infested with black thrips. Close observations with a hand lens revealed the insects feeding inside the shuck and on the young seed, in the milk or dough stage.

Specimens were placed in vials and sent to Dr. Stanley Bailey, University of California, Davis, California. He identified these thrips as *Chirothrips mexicanus* and *Chirothrips falsus*. These thrips are common in California but not injurious.

The injury to Bermuda grass was very evident in Yuma and a control was needed. After contacting several entomologists in the west, it was decided that a parathion dust would be the best to use since the chaff would be destroyed. Samples of 1 and 2 per cent parathion dusts were secured.[1] The dusts were applied by a ground machine at the rate of 15 to 18 pounds per acre. Three plots were staked off in a Bermuda grass field near Roll, Arizona, on August 12, 1948. Two were dusted and one was not dusted. Before applying the dusts, 100 heads were clipped from each plot. These were placed in a carton and taken to the laboratory for counts. Similar counts were taken every 3 days for a period of 2 weeks, as follows:

	Insect per 100 heads		
Date	*1% Dust*	*2% Dust*	*Check*
Aug. 11	120	98	116
Aug. 17	24	5	119
Aug. 20	10	2	125
Aug. 23	10	0	124

It was evident after the second clipping that the 2 per cent dust had done the job.

Two weeks after applying the dusts, it was evi dent to the naked eye that we had secured good results. The farmers immediately asked us to recommend the dust. We stated that the tests were only preliminary and that we could not recommend an insecticide like parathion with so few data. The price of Bermuda was 75 cents per pound and the growers needed control. The growers immediately ordered the 2-per cent dust and used 60,000 pounds of it in 1948.

In addition to the above experiment, we replicated the one above with 2 per cent parathion dust, 1 per cent of another dust and an emulsion spray with the same material at 0.25 pound per acre. The results showed good controls with the parathion and the emulsion spray of the new compound.

On November 30, 1948, the Extension Entomologist checked fields in the Yuma and Roll areas to determine what yields were being secured where 2 per cent parathion dusts were used and where no dusts were used. The fields that were dusted were producing yields of about 350 to 450 pounds of No. 1 seed per acre, while undusted fields were showing 30 to 50 pounds of seed per acre. The fields showing the low yields contained thrips around the borders on this date, while in treated areas no thrips were present.

Further experiments are needed for control of the scale insects and also to determine the injury that the white flies may cause. Also further experiments for control of the thrips are needed.

[1] From the American Cyanamid Company.

Control of Wireworms Attacking Sugar Cane in Louisiana

E. K. BYNUM, J. W. INGRAM, and L. J. CHARPENTIER,[1] *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

In areas along the Mississippi River in the vicinity of Edgard, La., wireworms of the genera *Melanotus*, *Conoderus*, and probably *Aeolus* so deplete the stand of cane planted in the fall as to cause heavy losses of the plant-cane crop and make it unprofitable to retain the fields as stubble cane. Cane is planted by laying the entire stalks of cane lengthwise in the bottom of the row furrows and plowing the soil back over them. When the cane is planted at the usual time in the fall, the wireworms gnaw out the eyes, or buds, of the seed cane during the fall and winter. One area of approximately 100 acres was so badly infested with wireworms that the production of cane was abandoned for several years.

In an effort to overcome such losses, an experiment was started during the summer of 1941 to compare summer planting with fall planting. Four replications of four varieties were planted at two periods—between August 1 and 15 and between September 20 and October 10. Each plot was three rows wide and 50 feet long. One half of each replicate was planted at the usual rate of two lines of stalks per row and the other half at three lines of stalks per row. All stalks were planted with the ends overlapping a few inches. The average number of plants obtained from counts made in six random 5-foot lengths of row per plot are given in table 1. When planted at the usual rate the stand of cane on the summer planting in April 1942, was more than double that from the fall planting, and that for C.P. 29/320 was over six times greater. Although in every variety at both dates of planting there was some increase in stand from planting three stalks of cane as compared with two stalks, this increase in nearly all tests was insufficient to pay for the extra cost of planting. Some summer planting was done on the same plantation the following year, and the results were favorable.

Table 1.—Stands of cane resulting from two rates of summer and fall planting in a wireworm-infested area. Number of plants per acre, estimated from counts made on April 22, 1942.

Variety	Three Lines of Seed Cane per Row		Three Lines of Seed Cane per Row	
	Summer-planted	Fall-planted	Summer-planted	Fall-planted
C.P. 29/116	39,270	10,950	44,550	14,250
Co. 290	19,470	8,730	21,270	11,460
C.P. 28/19	19,680	7,410	25,110	8,310
C.P. 29/320	21,870	3,450	23,310	6,840

During 1944 three experiments in summer versus fall planting were conducted, two in light soil and one in a mixed type of soil, with two varieties of cane in each experiment. The plantings were made between August 1 and 10, and on September 20. Plantings of each variety were replicated two or more times for each date of planting in each experiment. Each plot was three rows wide and extended the entire length of the field. Plant counts were made on March 23, 1945, in six to nine 25-foot lengths of row in each plot. The results obtained from these counts are given in table 2. From 7 to 22 times as many plants per acre came up in the summer-planted as in the fall-planted plots, and the stand of cane in the fall-planted plots was so poor that the yield was far below that of a normal crop.

Labor shortage, weather conditions, and lack of time to remove a preceding corn crop often make it difficult for growers in the wireworm areas to plant a large percentage of their acreage during the most favorable period in the summer. Thus it is necessary that they do considerable planting in the fall. The late planting would be damaged by wireworms unless protected during the fall and winter. A latin-square experiment was therefore started on Church Place Plantation near Edgard, La., on October 10, 1947, to determine the value of several insecticides

Table 2.—Stands of cane resulting from summer and fall plantings, 1944–1945. Number of plants per acre, estimated from counts made on March 23, 1945.

Plantation	Soil Type	Variety	Summer-planted Cane	Fall-planted Cane
Church	Light	C.P. 29/103	81,072	4704
		C.P. 34/120	119,328	5520
Johnson	Light	C.P. 34/120	118,880	8832
		C.P. 29/120	73,200	6000
	Mixed	C.P. 34/120	73,120	9920
		C.P. 29/120	44,832	6768

[1] W. E. Haley collaborated in the project here reported.

Table 3.—Plant counts on May 14, 1948, and yields from plots treated with soil insecticides for wireworm control.

Treatments	Active Ingredients, Pounds per Acre	Number of Plants per Acre	Cane, Tons per Acre	Sugar, Pounds per Acre
Chlordan	4	49,000	46.78	8015
Toxaphene	4	45,500	44.52	7709
Gamma benzene hexachloride	0.8	41,300	45.42	7375
DDT	4	26,300	39.46	6744
Check, no treatment		11,500	28.74	4646
Differences required for significance:				
1-per cent level		12,200		1399
5-per cent level		17,000		1962

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in protecting fall-planted cane from wireworm injury. The plots were three rows wide and 25 feet long, with five replications for each treatment and check. They were planted with two lines of seed cane per row, with the variety of C.P. 36/105. Dusts containing chlordan, toxaphene, gamma benzene hexachloride, or DDT were applied by hand on top of the seed cane at the rate of 400 pounds per acre, after which the cane was covered in the usual way. One per cent dusts were used for all insecticides except gamma benzene hexachloride, which was applied as a 0.2-per cent dust. The results of the plant counts made on May 14, 1948 and the yields obtained at harvest-time are given in table 3. All insecticidal treatments gave large increases in the number of plants per acre. The greatest increase was in the chlordan plots, which had more than four times as many plants as the check. The cane in all plots was harvested during a wet period and the trash was wet and not burned. The wet trash probably increased the tonnage by 10 or 15 per cent.

Since toxaphene gave almost as good control as chlordan and was cheaper, large-acreage experiments were started with that insecticide on fall-planted cane in 1948. The final results of these experiments are not yet available.

Experiments and observations show that summer-planted cane suffers little injury when planted in areas badly infested with wireworms. In such areas, therefore, cane should be planted in early August, when agronomically practical. However summer planting may increase borer injury in the plant-cane crop. The increase in yield though, through reduction of losses in stand caused by wireworms, should be many times greater than any loss resulting from increased borer injury.

The results from one experiment indicate that most of the wireworm injury to fall-planted cane may be prevented by applying 400 pounds of dust containing 1 per cent of chlordan or toxaphene, or 0.2 per cent of gamma benzene hexachloride per acre in the furrow with the seed cane at the time it is planted.

Parathion Dust for Control of the Pineapple Mealybug

MAX R. OSBURN, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*[1]

In 1948 preliminary tests were conducted at Fort Pierce and North Miami, Fla., to determine the effectiveness of parathion dust for control of the pineapple mealybug, *Pseudococcus brevipes* (Ckll.). This mealybug is responsible for a serious disease of pineapples known as pineapple wilt. It usually feeds at the bases of pineapple leaves near the ground level and on the roots below the soil surface.

A 1-per cent dust was used in all the tests. A rotary hand duster was used to apply the dust, which was discharged down into the center of each plant so that most of the dust would be deposited as near to the mealybug infestation as practicable. At intervals after the applications treated and untreated plants were selected at random, pulled out of the ground, torn apart, and examined for mealybugs.

At Fort Pierce a row of 180 large pineapple plants was treated on July 22 at the rate of 0.35 ounce of dust per plant. On August 20 27 treated plants and 27 untreated plants were examined for mealybugs.

At North Miami two adjacent pineapple beds, each containing 400 plants (4 rows wide by 100 plants long), were chosen for the test. One of the beds was treated on September 1 at the rate of 0.16 ounce of dust per plant. One half of the plants were re-treated on September at the rate of 0.24 ounce per plant. The other bed was not treated. The lighter dosages were used because in the Fort Pierce test excellent results had been obtained with a heavier dosage. Moreover, the plants were smaller than those used in the first test. On September 28, just before the second application was made, 100 of the treated plants and 100 plants from an untreated bed were examined for mealybugs. On November 17 similar samples from the one- and two-application plots and from the untreated bed were examined.

The results of the tests at both places are given in table 1.

Table 1.—Pineapple mealybug infestations following applications of a 1 per cent parathion dust.

TREATMENT (OUNCES PER PLANT)	APPLICATION DATES	PLANTS INFESTED*		
		Aug. 20	Sept. 28	Nov. 17
		Per Cent	*Per Cent*	*Per Cent*
Fort Pierce Test				
0.35	July 22	0	—	—
None	—	93	—	—
North Miami Test				
0.16	Sept. 1	—	13	19
0.16	Sept. 1	—	—	21
0.24	Sept. 29			
None	—	—	57	94

At Fort Pierce one application of the dust at the rate of 0.35 ounce per plant was completely effective for at least 4 weeks. In the North Miami test one application of the dust at 0.16 ounce per plant reduced the number of infested plants, but the mealybugs were not controlled as well as they were in the Fort Pierce test. The treatment continued to be effective during an additional interval of 7 weeks. Two applications of parathion seemed to be no better than one. However, all the mealybugs on the treated plants were found on the roots below the ground level, whereas most of those on the untreated plants were located at leaf bases slightly above the ground level. Probably the parathion did not reach the mealybugs that were infesting the roots below the soil surface.

Analysis by the Division of Insecticide Investigations, Bureau of Entomology and Plant Quarantine, of ripe pineapple fruits that had been dusted with parathion at the rate of 0.48 ounce per plant 7 weeks before maturity showed that the unpeeled, whole fruit contained only 0.01 p.p.m. of parathion. None was found in the flesh without peel.

The applications of parathion were not injurious to the pineapple plants.

[1] The assistance and cooperation of P. K. Platts, Fort Pierce [Fla.] pineapple grower, and of D. S. Radebaugh and S. K. Ferry, of the Miami [Fla.] Pineapple Plantation, are gratefully acknowledged.

Further Tests with Soil Insecticides to Control Southern Corn Rootworm[1]

WALTER M. KULASH, *North Carolina Agricultural Experiment Station, Raleigh*

Preliminary trials with soil insecticides for the control of the southern corn rootworm, *Diabrotica duodecimpunctata* Oliv., in North Carolina were reported by Fulton in 1946. In these tests, DDT and technical grade benzene hexachloride were used in spray and dust formulations to protect seed corn and seedlings from rootworm attacks. Tests with additional insecticides were planned for 1947 but because of dry weather conditions, the rootworm in the test plot areas never became abundant. Consequently, experiments for rootworm control were not conducted in 1947.

In 1948, weather conditions indicated that a wet spring might be in the offing and, consequently, heavy rootworm damage might be expected, especially in low areas of susceptible fields. Therefore, it was decided to continue tests with DDT and benzene hexachloride for rootworm control and, in addition, to try some of the other new insecticides.

MATERIALS USED.—The 1948 tests included 12 insecticidal treatments plus the untreated check treatment. Eight different insecticides were used.[2] These materials are listed in table 1. The concentration used and the rate per acre of active ingredients are also listed in table 1. All materials were used in the dust form.

METHOD OF TESTING.—Each treatment was applied to single row plots 50 feet long, and replicated twice. Rows were spaced the normal distance of three and one-half feet apart. Treatments were randomized except in the case of the untreated checks. Every third row was designated as an untreated check row. In such an arrangement, every treated row was adjacent to an untreated row which served as a check row. The possibility of localized distributions of rootworms within small areas made it desirable to have frequent check rows. The arrangement of check rows in this study permitted comparison of treated rows with adjacent untreated rows.

Table 1.—Summary of materials used for rootworm control and percentage of rootworm-damaged plants.

MATERIAL	POUNDS OF ACTIVE INGREDIENT PER ACRE	PERCENTAGE OF PLANTS DAMAGED BY ROOTWORMS[1]	
		In Treatments	In Nearest Check
Chlordan	4.0	2.5	33
Benzene hexachloride (Technical grade)	0.2[2]	3.0	31
Benzene hexachloride (Technical grade)	0.4	3.5	30
Parathion	1.0	4.5	31.5
Parathion	2.0	5.0	23.0
Ditoyl trichloroethane	10.0	11.5	32.5
DDT	10.0	11.5	36.0
Alpha, beta Benzene hexachloride[3]	10.0	12.0	26.0
DDT	5.0	14.0	32.0
Methoxychlor	10.0	16.5	28.0
Toxophene	10.0	19.5	27.0
Ditolyl trichloroethane	5.0	21.0	26.0
Untreated check, average of all plots		29.4	
Untreated Golden Cross		26.7	
Untreated MC78		32.0	
		(L.S.D., 5% level, 7.31)	

[1] Based on five counts at three day intervals in two replicates of plots consisting of 50 lineal feet of row.

[2] Amount of gamma isomer used per acre as technical grade benzene hexachloride.

[3] By-product of manufacturer of purified gamma benzene hexachloride composed of the alpha and beta isomers of benzene hexachloride. Supplied by the Penn. Salt Mfg. Co., Philadelphia.

Corn was planted by hand at a depth of 2 inches, one seed being dropped at each 4 to 6 inch interval in the drill. In all the insecticidal treatments, the sweet corn hybrid MC78 was used. In the untreated checks, rows were planted alternately to MC78 and Golden Cross Bantam. The reason for planting the two hybrids in alternate check rows was to observe their performance under normal conditions of planting, that is, without the use of a soil insecticide.

The different formulations were prepared so that 100 grams of the finished dust, applied to each 50 feet of row in a strip one foot wide, would carry the desired amount of active ingredient per acre. A furrow 4 inches deep was run by hand. Fertilizer was distributed into the furrow and covered over slightly with soil. Then the insecticide was sifted with a hand sifter to the entire 50 feet of row in a strip 1 foot wide, that is, 6 inches to each side of the center line of the furrow. A stick was dragged down the furrow to mix the insecticide with the soil. The seed was then dropped by hand and covered with soil to a depth of 2 inches. This method of insecticide application and planting surrounded the seed with treated soil. Thus was insured a contact action on rootworms already in the soil or on those hatching from eggs. The number of seeds planted in each 50 foot plot was noted in order that effects on germination could be observed.

In the first replicate, the planting was done on April 30 and in the second replicate on May 4. In both replicates the seedlings were up 10 days after planting. By two weeks after planting, the seedlings were large enough to show any damage due to rootworm attack. Rootworm-damaged plants were readily recognized by the pronounced wilting of the "bud" of the seedling. The rootworm-damaged plants were counted six times at three-day intervals, starting on May 15 in the first replicate and on May 18 in the second replicate. The number of plants which emerged was also noted. Damaged plants were removed after each count, and all plants were examined for rootworm injury in the underground portion of the stem just above the seed. In most instances, the rootworm was found in the stem, or nearby in the soil.

RESULTS.—As an index of control a percentage figure, total damaged divided by total emerged, was computed. The percentages for the two replicates were averaged and are listed under the column headed "Percentage of Plants Damaged" in table 1. All treatments were significantly better than the check, which had an average "percentage of plants damaged" of 29.4. Treatments that had five or less per cent of plants damaged were technical grade gamma benzene hexachloride at 0.2 and 0.4 lbs. per acre, chlordan at four pounds per acre, and parathion at one and two pounds per acre. The percentage

[1] Contribution from the Department of Zoology and Entomology, North Carolina Agricultural Experiment Station, Published with the approval of the Director as Paper No. 316 of the Journal Series.

[2] Materials used in these tests were supplied by: Pennsylvania Salt Manufacturing Company, Philadelphia; Geigy Company, New York; California Spray Chemical Company, Elizabeth, New Jersey; Velsicol Corporation, Chicago; E. I. du Pont de Nemours, Wilmington, Delaware; and the American Cyanamid Company, New York.

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of damaged plants in the other treatments ranged from 11.5 per cent for DDT at 10 pounds per acre to 21.0 per cent for ditolyl trichloroethane at five pounds per acre.

There was no significant difference in the amount of rootworm injury between MC78 and Golden Bantam Cross.

The maximum number of rootworm-damaged plants was recorded on May 24. This was true for both replicates despite the fact that the second replicate had been planted some days later than the first replicate. At this time plants averaged five to six inches high in the first replicate and three to four inches high in the second replicate. The total of rootworm-damaged plants on all of the treatments at the several dates were as follows for each replicate:

	Replicate number	
	1	2
DATE	Damaged Plants	Damaged Plants
May 15	16	—
May 18	38	25
May 21	30	35
May 24	57	52
May 27	23	26
May 30	26	36
June 3	—	14

A statistical analysis of rates of germination showed that there was no difference in germination that could be ascribed to the action of any of the insecticides. The roots and foliage of plants in the treated rows were not noticeably different from the roots and foliage of the untreated check plants.

DISCUSSION.—It appears that the use of soil insecticides in the furrow may be a practical means of controlling the southern corn rootworm as a pest of corn. Before this method can be recommended for general use with any of the new insecticides, however, certain problems must first be evaluated properly. Chief among these are the effect of soil insecticides on the micro-biology of the soil, the possible off-flavor that may be imparted to plants, especially root vegetables which might sooner or later be planted on treated soil, and the general effect of accumulation of insecticides in the soil.

SUMMARY.—Eight insecticides, in 12 dust formulations, were used as soil poisons in tests for the control of the southern corn rootworm attacking corn seedlings. The dusts were applied to the drill and the corn was planted immediately after. The actual amount of active ingredients used per acre ranged from 0.2 pound of gamma benzene hexachloride to ten pounds of DDT. A sweet corn hybrid, MC78, was used in all the treated plots. In the untreated checks, two hybrids were used. These were MC78 and Golden Cross Bantam.

The lowest percentage of rootworm-damaged plants, 2.5, was recorded in the treatment with chlordan at the rate of 4 pounds per acre. The highest percentage of rootworm-damaged plants, 29.4, occurred in the untreated check plots. Methoxychlor at 10 pounds per acre and ditolyl trichloroethane at 5 pounds per acre were less effective than DDT at ten pounds per acre. Other materials used included chlordan, parathion, chlorinated camphene, and alpha-beta benzene hexachloride. All of these treatments gave significantly lower damage than the check.

There was no observed difference between MC78 and Golden Cross Bantam with respect to rootworm injury. There was no observable effect on germination or on roots and foliage resulting from the use of these insecticides at the rates employed.

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Strawberry Weevil Control with New Organic Insecticides

E. G. CHRIST and B. F. DRIGGERS, *New Jersey Agricultural Experiment Station, New Brunswick*

The strawberry weevil, *Anthonomus signatus* Say, has been a pest of economic importance on strawberries for a long time. It has been especially damaging in fields planted along side woods, brushy hedgerows or other cover supplying suitable hibernating quarters for the adult weevils. An arsenical dust diluted with lime or sulfur in the ratio of 1 to 5 has been a more or less standard control material for a number of years. In recent years complaints were received from certain growers in southern New Jersey to the effect that the arsenical-sulfur dusts as recommended were not giving satisfactory control.

One of these plantings in the Hammonton area was selected for testing several of the new organic insecticides in comparison with the standard lead arsenate-sulfur dust mixture. Two row plots 30 feet long were laid out on the side of a strawberry field adjoining a woods. The four dust mixtures were applied on April 29 when first beetles were noted depositing eggs and a second application was made on May 7 when the adult weevils were at their peak of emergence and activity. Approximately 40 pounds of each of the dust mixtures were used per acre per application.

The effectiveness of the dust treatments was determined by collecting 100 flower clusters from each of the four treated plots and from an untreated check plot on May 14. The total number of buds and the percentage of buds destroyed by the weevils were determined. The results are set forth in table 1.

The data in table 1 show that the standard lead arsenate-sulfur dust and the 5-per cent toxaphene were only partially effective in controlling the strawberry weevil. The reduction in percentage injury over the untreated check was approximately 50 per cent with both of the treatments. The reduction with the 1 per cent benzene hexachloride and 5-per cent chlordan was 93.5 per cent and 85.5 per cent respectively which would indicate that further tests with these two insecticides as a control for strawberry weevil would be desirable.

Table 1.—Strawberry weevil control with several dust formulations used in two applications at 40 pounds per acre.

TREATMENT	TOTAL BUDS	BUDS DESTROYED
Toxaphene (5%)	334	19.1%
Refined benzene hexachloride (1% gamma isomer)	372	2.5
Chlordan (5%)	303	5.6
Lead Arsenate-Sulfur (1:5)	306	19.0
Check (untreated)	352	38.6

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Periodic Colonization of *Chrysopa californica* as a Possible Control of Mealybugs

RICHARD L. DOUTT and KENNETH S. HAGEN, *Division of Biological Control, University of California*

In preliminary field tests *Chrysopa californica* Coq. was able to suppress the populations of a mealybug, *Pseudococcus* sp.,[1] on pears and to hold them under natural control in the absence of insecticidal sprays (Doutt 1948). Subsequent tests showed that while the DDT sprays were injurious to the adult *Chrysopa*, the larvae were able to survive and mature after being sprayed with the normal concentration of DDT used in California pear orchards (1.5 lbs. 50 per cent wettable DDT per 100 gals.).

Observations indicated that natural field oviposition by the female *Chrysopa* from the overwintering population began at about the time when the first DDT spray was applied. Although the date of the initial spray application may vary from year to year it is timed by petal fall, which is probably dependent upon the same basic natural factors that stimulate oviposition by the overwintering adult *Chrysopa*. The concurrent nature of these activities often results in a scarcity of *Chrysopa* eggs in sprayed orchards, and permits the mealybug to increase in the absence of a natural enemy.

It was felt that control of mealybugs might be achieved by artificially supplying the sprayed pear trees with *Chrysopa* eggs to overcome the deficiency caused by the early applications of DDT. For this purpose a technique for the mass production of *Chrysopa* eggs was developed (Finney 1948) which proved successful and supplied quantities of eggs for field work.

The field trials on *Chrysopa* egg colonizations were divided into three categories, and each test plot (each plot consisting of 4 trees) was thrice replicated. Trial A consisted of 23 periodic colonizations continued throughout the entire season from January until October, and totalled approximately 14,000 eggs per tree. Trial B was conducted as an early season experiment from January until April, and was composed of 6 colonizations totalling 5000 eggs per tree. Trial C, designed as a summer test, was begun in May and discontinued in August. The investigation in category C was composed of 9 colonizations totalling 4500 eggs per tree.

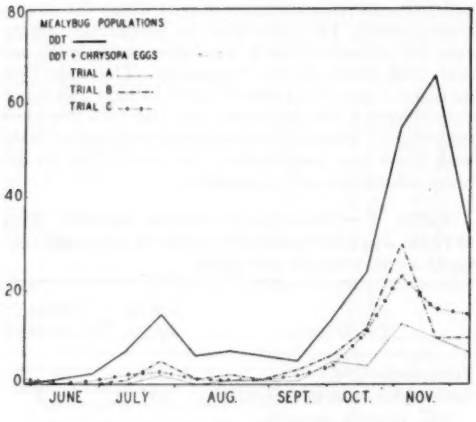

FIG. 1.—Comparative populations of the mealybug in DDT plots with and without colonization of *Chrysopa californica* eggs.

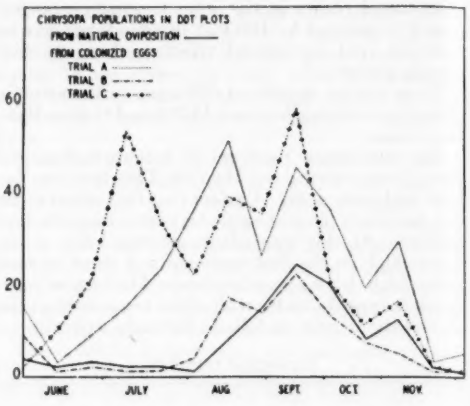

FIG. 2.—Comparative populations of *Chrysopa californica* in DDT plots with and without colonization.

Throughout the season the host and predator populations in each plot were sampled by making biweekly counts of the mealybugs and *Chrysopa* pupae in the trunk bands of the four trees. The data from all replicates were combined and are graphically presented in figures 1 and 2.

The mealybug populations existing in plots subjected to continuous colonizations (Trial A) or to summer colonizations (Trial C) were substantially lower than those recorded from corresponding check plots, figure 1. The early season colonization program (Trial B) was less effective and resembled the check plots. The data suggest that in the course of this experiment the law of diminishing returns became operative, for the end result of 23 colonizations is not in proportion to the end result of fewer colonizations of a smaller number of *Chrysopa* eggs.

The *Chrysopa* populations resulting from egg colonizations in sprayed trees are compared graphically with those populations arising from natural oviposition in other DDT-treated trees used as check plots, in figure 2. These investigations suggest that the colonizations made between April and June exerted the most influence on the suppression of mealybugs. These field studies indicate that while the technique shows promise as a possible method of mealybug control further investigations are necessary to determine the proper timing and the minimum colonizations required.

SUMMARY.—Although adults of *Chrysopa californica* Coq. are sensitive to DDT and oviposition is inhibited by the presence of this insecticide, the larval stage is able to survive field spraying. The deficiency of naturally oviposited *Chrysopa* eggs in DDT-treated pear trees was overcome by colonizing eggs produced in an insectary. Colonizations performed during the spring and summer months suppressed the mealybug populations, but early season colonizations were less effective.

[1] The taxonomy of the so-called "*maritimus* complex" is still so uncertain that it seems best not to apply the name *Pseudococcus maritimus* to this species at this time.

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Control of Aphids on Tobacco

NEELY TURNER, *Connecticut Agricultural Experiment Station, New Haven*

Aphids have been present on Connecticut tobacco in insignificant numbers for many years. In common with other areas, a moderate infestation developed in 1946, and in 1947 serious damage occurred. The reason for this sudden development has not been found as yet. One fact worth noting, however, is that it happened simultaneously with the large-scale application of DDT to potatoes. Bronson & Smith (1946) reported excellent control of the green peach aphid following application of DDT. No mention of a repellent effect of DDT for this aphid has been made in the literature, but Kennedy (1947) has shown that sublethal contacts of mosquitoes on DDT residues produced a repellent or excitant effect. It seems reasonable to consider that widespread use of DDT on potatoes may have contributed to the presence of these aphids on tobacco.

The first attempts at control disclosed that the standard aphicides were not very effective.[1] Further evidence was provided by the work of Wilson *et al*, (1948). It has not as yet been determined whether this failure was caused by resistance of the aphids to these materials, or by an unusually high biotic potential of the aphids. However, it was necessary to find a suitable material and particularly one adaptable for application by aircraft or mist blowers rather than by row-crop equipment.

Preliminary tests by Greenwood[1] showed that dusts and sprays containing chlordan were not very effective. Benzene hexachloride dusts were also relatively poor, but sprays were excellent. Parathion dusts were by far the most effective.

In 1948 an infested plant bed was divided into plots and dusted on June 10. Counts of the number of plants infested by aphids were made at weekly intervals and are given in table 1. Parathion dust was most effective over the entire period of the test. Chlorinated camphene dust produced a fair initial kill but did not prevent reinfestation. Gamma benzene hexachloride and DDT were intermediate in effectiveness. In addition to these tests, 10 per cent DDT dust was applied as a preventive treatment to uninfested plants on June 10. On June 23 only 4 per cent of these plants were infested, while the two untreated plots on either side averaged 88 per cent infested. These results indicate that DDT has considerable value as a repellent or preventive treatment for these aphids.

Three field tests were carried out on a relatively large scale in cooperation with tobacco growers and insecticide manufacturers. On July 7 biplanes applied three types of parathion sprays on shade-tobacco of the American Sumatra Tobacco Corporation in Windsor Locks, Connecticut. These materials[2] were a 25 per cent wettable powder a 20 per cent emulsion with di-2-ethyl hexyl phthalate as the solvent and a 20 per cent emulsion with amyl acetate solvent. Dosage was adjusted to apply about 0.2 pound parathion per acre in 3.5 gallons of water. The tobacco in these tents was about 2 feet high and no aphids were present. Small potted tobacco plants were placed on the ground between the field plants field plants just before spraying. They were removed 3 hours later and held 48 hours for examination.

No aphids survived following application of the phthalate emulsion. One of the four plants exposed to the wettable powder had a few living aphids. The amyl acetate emulsion was much less effective, but the distribution of this treatment from the plane was observed to be faulty.

On July 14, another airplane test was made by the same grower, using gamma benzene hexachloride[3] wettable powder at the rate of one-half pound gamma isomer per acre in 3.5 gallons of water. Aphids were counted on potted plants left in the tent for 3 hours after treatment (Table 2). Mortality on individual plants varied from 51 to 90 per cent, which was fairly good considering the small size of the infested plants.

On August 4 several small fields of sun-grown tobacco on the grounds of the Tobacco Laboratory at Windsor, Connecticut, were treated by the Imperial Agricultural Corporation, using a mist blower. Parathion wettable powder was applied at the rate of about 4 ounces parathion per acre in 8 gallons of water. The material was all applied from the borders of the fields. The effective swath was about 100 feet. Infested plants tagged before treatment were examined a week later. In general the control was excellent. No living aphids were found except on two plants in the center of a field too large to be covered by the blower, and on a few plants on the margins

[1] Unpublished notes of D. E. Greenwood, at that time a staff member of the Connecticut Agricultural Experiment Station.
[2] Furnished by American Cyanamid Company, New York.
[3] Furnished by California Spray Chemical Corp.

Table 1.—Results of single-plot seed bed tests of dusts to control aphids. Dusted June 10.

MATERIAL	NUMBER OF PLANTS					
	June 16		June 23		June 30	
	Infested	Clean	Infested	Clean	Infested	Clean
Parathion 1%	0	50	0	50	4	46
Chlorinated camphene 10%	5	45	reinfested		—	—
DDT 10%	10	40	7	43	8	42
Gamma benzene hexachloride 1.5%	4	46	4	46	2	48
Untreated	50	0	—	—	45	5

Table 2.—Results of airplane application of gamma benzene hexachloride sprays for aphid control.

Plant No.	Number of Aphids		Per Cent Reduction
	July 14	July 19	
1	103	29	72
2	114	56	51
3	105	23	78
4	300	69	77
5	210	36	83
6	128	37	71
7	132	57	57
8	96	10	90
9	142	26	82
10	96	11	89
11	145	14	90
12	130	21	84

of the field too close to the nozzle to be covered. It would be well to mention that this mist blower was used successfully to control flea beetles and aphids on about 1000 acres of shade tobacco.

SUMMARY.—Aphids appeared in numbers on tobacco in 1946, and caused serious damage in 1947.

The fact that this appearance coincided with large-scale use of DDT on potatoes, normally infested by the same aphid, suggests that a repellent effect of DDT may be involved.

Applications of DDT to uninfested plants in seed beds prevented infestation to a great extent.

Small-plot tests showed that one per cent parathion dust was more effective than 1.5 per cent gamma benzene hexachloride, or 10 per cent DDT, and that 10 per cent chlorinated camphene was still less effective.

Airplane applications of concentrated sprays of parathion wettable powder and emulsion at the rate of about 0.2 pound parathion per acre were remarkably effective.

Airplane applications of about 0.5 pound gamma benzene hexachloride per acre as a wettable powder in concentrated form produced a fair control of aphids on small plants.

Mist blower application of about 0.25 pound parathion per acre as a wettable powder in 8 gallons of water killed all the aphids reached by the treatment.

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Insecticides Tested Against the Willamette Mite on Red Raspberries[1]

CARL JOHANSEN[2] and E. P. BREAKEY[3]

The following insecticide tests and observations on the control of the Willamette mite, *Tetranychus willamettei* McG., on red raspberries in the Puyallup Valley were made in 1948. This is a continuation of the work begun in 1947.[4]

MATERIALS.—1. A spray powder,[5] 20 per cent dicyclohexylamine salt of dinitro-o-cyclohexylphenol; and a dust,[5] 1.8 per cent dicyclohexylamine salt of dinitro-o-cyclohexylphenol.

2. A sulfur dust,[6] 42 per cent sulfur fused with bentonite.

3. A tetraethyl pyrophosphate concentrate,[7] 10 per cent tetraethyl pyrophosphate and 15 per cent other ethyl phosphates in an emulsible base; tetraethyl pyrophosphate dusts,[8] 0.5 to 1.0 per cent; and a 25 per cent tetraethyl pyrophosphate spray concentrate.[9]

4. A rotenone spray concentrate,[10] 1.5 per cent rotenone in an emulsible paste; a 2.5 per cent rotenone spray concentrate.[8] Rotenone was tested only as a mite control in combination with tetraethyl pyrophosphate.

5. Seventy-five per cent lauryl sulfides of alkyl-2-thiozolinyl.[11]

6. Parathion,[12] 0.5 per cent diethyl p-nitrophenyl thiophosphate.

METHODS.—The Willamette mite plots were designed in blocks rather than in randomized plots because of the danger of the dust drift influencing the results. Counts were made by picking 25 leaflets at random (low and inside, where the mites were most numerous) through the center of each block. Only the living mites were counted. It was believed that such counts made at intervals would yield more accurate data than fewer counts taken of living mites, dead mites, and eggs.

The acaricides gave consistently better results when applied as dusts for the control of the Willamette mite on red raspberries. Moreover, the dusting equipment could be drawn more easily between the raspberry rows late in the season when the mite population was increasing. It was found that the dusting machinery could be adapted to the application of dusts for the control of mites in red raspberries by directing the nozzles or "fish-tails" very low so that the dust materials would billow up through the foliage.

EXPERIMENTAL RESULTS.—Tetraethyl pyrophosphate was the most promising material tested and was recommended to growers who had a mite problem at picking time. The most outstanding results obtained by using this material were those of a grower who had an infestation in one of his raspberry fields of 3000 mites per 25 leaflets on July 15. He obtained a 0.5 per cent tetraethyl pyrophosphate dust and applied it at the rate of 30 lbs. per acre on July 24. Although it was thought that two applications 5 to 7 days apart would be necessary for good control, only one application was made. A check was made August 6 and only 3 mites per 25 leaflets were found.

[1] Published as Scientific Paper No. 827, Agricultural Experiment Stations, Institute of Agricultural Sciences, State College of Washington. The contribution of certain funds by the Washington State Department of Agriculture as a grant in aid for research, made it possible to increase the scope of this project.

[2] Assistant in Entomology.

[3] Associate Entomologist, Washington Agricultural Experiment Stations.

[4] Journal of Economic Entomology, 41: 805–806, 1948.

[5] *DN-11* and *DN-D-8*, Dow Chemical Co.

[6] *Kolodust*, Niagara Chemical Division.

[7] *Lathex*, Vis-Ko, Inc.

[8] *Hexide* dusts and *Neurote*, Niagara Chemical Division.

[9] *Vapatone*, California Spray Chemical Corporation.

[10] *D-24*, Vis-Ko, Inc.

[11] *IN-4200*, du Pont, Inc.

[12] *Thiophos 4322*, American Cyanamid Co.

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Tetraethyl pyrophosphate, when applied as a dust, gave consistently better results than when applied as a spray. Bests results were always obtained with either a dust or a spray when it was applied during the warmest part of the day.

The lauryl sulphides compound also showed promise, but it had to be dropped from the experiments at picking time because of incomplete knowledge as to its toxicity.

In many cases, raspberry growers incorporated either the dinitro compound or sulfur in one or more of the sprays or dusts applied for the control of the orange tortrix, *Argyrotaenia citrana*, early in the season. These acaricides helped keep the Willamette mite population low at that time. It was thought that the use of dichlorodiphenyl dichloroethane for the control of the orange tortrix might encourage the mite populations. However, this was not true. Growers in the Puyallup area who used the material apparently did not experience any greater mite damage than those who used cryolite for control of the orange tortrix.

PHYTOTOXICITY.—Considerable injury resulted from the use of dinitro sprays and dusts when applied to control the Willamette mite on red raspberries. Excessive strengths caused this injury and the problem was eliminated by using this material at a maximum of 4 ounces of the dinitro spray powder per 100 gallons of water.

The application of sulfur dusts for mite control during hot weather caused severe burning of the foliage of red raspberries, and may be one cause of the so-called "crumbly berries" that developed in a number of fields. This damage was especially severe in fields where the sulfur had been applied just previous to three unusually warm days for this region; June 7, 8, and 9, with a maximum temperature of 82° F. No cases of injury arising from the use of wettable sulfur in a spray were noted.

NOTES ON BIOLOGY OF THE MITE.—Willamette mites were found in the raspberry fields in very small numbers as early as the second week in April, 1948. Heavy infestations had developed in a few scattered fields by June 1 and were found in many fields by the end of July. There is mounting evidence that heavy mite infestations late in the season may stimulate fall growth, causing severe "winter kill" of the tops of the canes, which is very evident the following season. The cool wet weather which prevailed in western Washington through the 1948 season undoubtedly kept the Willamette mite from causing severe damage.

Specimens were sent to E. A. McGregor for identification several times during the season. Each time they were identified as *Tetranychus willamettei* McG. Apparently, we are working with an unmixed population of this mite.

Two predators, a small black lady beetle, *Stethorus picipes* Csy., and a small dark colored hemipteron, *Orius insidiosus* Say, were abundant in fields that were heavily infested with mites.

CONCLUSIONS.—Tetraethyl pyrophosphate gave the best results of the materials tested (dinitro compounds, tetraethyl pyrophosphate, sulfur, rotenone, lauryl sulphide compounds, and parathion) as a control for the Willamette mite. The dinitro compound and sulfur were hazardous to use because of their phytoxicity and parathion because of the possible residue and its toxicity to warm-blooded animals.

Recommendations for the control of the Willamette mite in western Washington in 1949 will include a dinitro compound, used sparingly, in the sprays and dusts applied for the control of the orange tortrix and tetraethyl pyrophosphate for late-season build-up of the mite population.

MEETING OF THE GEORGIA ENTOMOLOGICAL SOCIETY

The thirteenth meeting of the Georgia Entomological Society was held at Jekyll Island near Brunswick, Georgia, on April 30, 1949. Eighteen persons attended. Papers on peach-insect control, evaluation of organic insecticides against the Mexican bean beetle, present status of control work on the white fringed beetle, and the Georgia cotton pest survey were presented by Oliver I. Snapp, Richard H. Washburn, G. G. Rohwer, and P. M. Gilmer, respectively. Moving picture reels on various uses of the Bell helicopter and on the five main insect pests of cotton (U.S.D.A. film) were shown.

Officers elected were John C. Alden, Woolford Chemical Company, President; F. J. Bartlett, U. S. Bureau of Entomology and Plant Quarantine, Vice-President; and H. O. Lund, University of Georgia, Secretary-Treasurer.

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Insecticides and the Food Law

In inviting a representative of the Food and Drug Administration to speak to your meeting on the subject of pesticides and the food law, the Chairman of your program committee indicated the deep interest of himself and members of the Association in the public-health problems of the newer insecticides. It is with the protection of the public health, of course, that the food law is most concerned.

In drafting the applicable provisions of the Federal Food, Drug, and Cosmetic Act of 1938 the Congress recognized that chemicals control are essential to the production of the Nation's food. Its policy is in entire accord with the statement in the November 1948 issue of *AIF News:* "Chemical pesticides are essential to the efficient functioning of modern agriculture. They are here to stay. Their use will be increased. Their effective use is vitally dependent upon a knowledge of their limitations as well as their benefits, and also upon a recognition of the hazards inherent in their application."

The policy of Congress as expressed in the law was prophetic in its recognition of the need for protecting public health against the unnecessary or uncontrolled use not only of insecticides but also of toxic substances that might be used as preservatives, emulsifiers, and otherwise in scores of items of our food supplies. Literally hundreds of chemicals have been used or proposed for use for these purposes within the past few years, particularly during the war when problems of food preservation and utilization were most acute.

The food law of 1938 prohibits interstate traffic in foods that are adulterated. It attacks the problem of protecting the public against poisons in foods by defining any food as adulterated if it contains a poisonous or deleterious substance which may be injurious to health; or if it contains any such substance that is not required in the production of the food or that can be avoided by good manufacturing practice; or where it is so required or cannot be so avoided, if it exceeds the tolerance prescribed by the Federal Security Administrator after public hearing. In prescribing a tolerance the law directs the Administrator to take into account the extent to which the poisonous or deleterious substance is required or cannot be avoided in the production of each food and the other ways in which the consumer may be affected by the same or other poisonous or deleterious substances. In every event the Administrator is enjoined by the statute to prescribe the tolerances at such levels that the public health will be protected.

One cannot read the statute without being impressed with the clear intent of Congress to go further than merely insuring that no single food will itself carry enough poison to jeopardize the health of the consumer. The purpose was to safeguard the Nation's food supply so that the over-all quantity of toxic substances, in all the items that make up the variegated diet characteristic of American people, will be held at safe levels.

As throwing further light on the purposes of the law, the language chosen to prevent the unnecessary addition of poisons is worthy of careful study. To repeat what was stated a moment ago, this language prohibits traffic in food containing any added poisonous or deleterious substance "except where such substance is required in the production thereof or cannot be avoided by good manufacturing practice." It will be noted that the word "required" is used. While the meaning of this word has not yet been interpreted by appellate courts, it seems fair to assume that a real or fancied improvement in the product resulting from an added poison would not be enough; that to satisfy the

law the added substance actually must be essential to production. It appears that Congress regarded the addition of poisons to our food supply as too hazardous to permit except in the face of a real necessity.

Some further light on the intent of Congress is shed by committee reports on the bill which became the present law. The following is a quotation:

> . . . In promulgating such regulations [prescribing tolerances] this section requires that there be taken into account the extent to which the use of the poison is required in the production of the article, as for example, poisonous sprays in producing certain fruits and vegetables, and likewise, the other ways in which the consumer may be affected by the same or other poisonous or deleterious substances. This authorization will permit the establishment of comparatively liberal tolerances for any food where poison is unavoidable or is required by the necessities of production, and less liberal tolerances or complete prohibitions where it is practicable to limit the amount of poison in a particular food to very small quantities, or to eliminate it completely. It will likewise afford adequate control of those situations where irresponsible manufacturers, for some fancied or real commercial advantage, add dangerously toxic substances to foods, as, for example, the addition of maleic acid to fats and oils to prevent rancidity when preservation can be accomplished by observance of sanitary conditions in manufacture and packaging and by use of refrigeration for the finished product. . . .

The new era in insecticides ushered in by the advent of DDT has brought with it a host of public-health problems. Accurate knowledge of the seriousness and extent of those problems is not keeping pace with the development and use of the newer pesticides. While manufacturers of the newer products and the entomologists who guide their use have in general recognized their obligations and their responsibilities to the public health, it is apparent that too many of the newer products have been rushed into production and use before sufficient investigation of their potential hazards and before users are sufficiently educated to avoid procedures that unnecessarily contaminate foods and thus jeopardize public safety.

I cannot stress too strongly the necessity for a thoroughgoing investigation of all phases of toxicity of every insecticide intended for use in connection with food production where there is any likelihood that even the merest trace may remain in or on the food at the time of consumption. To produce and use any product before this basic research work has been done is to invite disaster in terms of human suffering and life.

To commercialize a poison before its potentialities are known is simply to use the public as guinea pigs. We cannot accept the cynical viewpoint of the man who was warned that the premature marketing of his poison might kill people and replied, "Well, I know, but somebody is killed every five minutes on the highway." It is true that a proper investigation of toxicity is expensive and time-consuming, but it is equally true that this is a far more sound and prudent investment than to rush into production and use without the insurance against disaster that such investigations give. As an organization vitally interested in this problem, the Food and Drug Administration's Division of Pharmacology will be glad to discuss with anyone who is interested the scope and kind of investigations it believes, through its experience, should be carried out before new products are exploited.

To appraise properly a new insecticide that may be used in food production, the tests required may be many and varied. In addition to the work needed to demonstrate its value for its prospective use accurately quantitative analytical methods must be devised, its toxicity to animals and man must be thoroughly explored, and the quantities to which they may be exposed must be determined. It is not enough to find the quantity remaining on the exterior of a fruit or vegetable as residues from dusting or spraying. Does it get into the interior through translocation or direct absorption or by being picked up from contaminated or treated soil by the root system of the growing plant? And when consumed by animals or man is it excreted in milk? Is it stored in the tissues? If so stored in slaughter animals will the meat be safe? These are but a few of the questions that must be answered.

The need for precautionary measures in producing and using pesticides and related products is receiving more and more public attention. An editorial in the August 28, 1948, *Journal of the American Medical Association* says, "The development and use of new pesticides and herbicides have created public health hazards." It then outlines the problem and continues:

> Voluntary control by the producers and distributors of these substances should be instituted im-

mediately. If voluntary control proves to be inadequate for the protection of the public, suitable legislation must be considered and effective means of control promptly established. At present governmental agencies find it difficult to protect the public from this potential hazard; existing agencies seem to doubt their authority and lack the funds to establish control. Prompt voluntary action by the industry is therefore imperative. The effectiveness of this action will determine the degree of governmental control ultimately required.

. . . Even though added controls may impede the development of pesticides, these are essential precautions which must be taken in order to avoid the danger of mass poisoning, which might well offset the potential benefits of the new agents.

That the industry is aware of the concern thus publicly expressed is shown by quoting again from last month's issue of the *AIF News:*

. . . legislation is frequently proposed as the solution to the problem. Legislation alone is not the answer. . . .

In the final analysis, the user—be he farmer, home gardener, householder or public servant—has the freedom of choice of the materials he uses, and no one wants it otherwise. But freedom brings responsibilities to both the manufacturer and the user and unless both accept those responsibilities, hazards will continue to plague all who have reason to be interested in effective pest control—and that means the public generally.

C. W. CRAWFORD,
Deputy Commissioner of Food and Drugs

Cumberland-Shenandoah Spray Conference

The twenty-fifth consecutive annual Cumberland-Shenandoah Spray Conference was held in Martinsburg, West Virginia, on November 26 and 27, 1948, with headquarters at the Hotel Shenandoah. The meeting was, as in other years, arranged so that there were general sessions at the beginning and at the end of the conference. The first general session was followed by the separate meeting of the entomologists and pathologists in attendance.

In the insect and disease section reports were given by representatives of each of the states represented as well as by the representatives of the United States Department of Agriculture. These reports were thoroughly discussed and after the discussion the formulation of the general spray recommendations for the coming season was accomplished. This practice has been followed from the start of the Conference in order to avoid apparently conflicting recommendations from the different states, this being especially necessary because there is much overlapping of the orchard interests into two or more states. Special recommendations were announced in several cases for areas in which conditions do not conform to those found in the typical orchard sections of the area.

As will be seen in the list of those in attendance there were representatives from six states, the Federal Government and the Boyce Thompson Institute.

The 1949 Conference will be held in Winchester, Virginia, under the chairmanship of Dr. A. H. Teske, of Blacksburg, who succeeds Dr. J. G. Leach, the 1948 Chairman of the Conference. M. L. Bobb of Blacksburg will preside over the Disease and Insect Section, of which Mr. J. H. Hill will act as Secretary.

The following persons were in attendance at the meetings of the Insect and Disease Section of the conference:

Virginia
M. L. Bobb
A. B. Groves
C. H. Hill
W. S. Hough
A. H. Hurt
A. H. Teske

West Virginia
Edwin Gould
J. G. Leach
C. R. Orton
L. M. Peairs
E. C. Sherwood
C. F. Taylor

Maryland
E. N. Cory
T. L. Bissell
C. Graham
W. T. Jeffers
G. S. Langford
L. O. Weaver

Pennsylvania
Dean Asquith
R. S. Kirby
F. H. Lewis
J. O. Pepper
H. W. Thurston, Jr.

U.S.D.A.
Howard Baker
J. C. Dunegan
M. C. Goldsworthy
E. O. Hamstead
J. R. Magness
Ben A. Porter

North Carolina
C. N. Clayton
J. T. Connard
H. R. Garriss
Clyde F. Smith

Delaware
J. W. Heuberger
L. A. Stearns
R. F. Stevens

Boyce Thompson Institute
S. E. A. McCallan

A. L. BURROUGHS IN JAPAN

Dr. A. L. Burroughs, Assistant Professor of Entomology, University of Minnesota, has been granted leave of absence for a year to work with the Army in Japan on B-encephalitis.

Report of the Twenty-Sixth Annual Meeting of the Entomological Society of Pennsylvania

Twenty-seven members attended the Twenty-sixth Annual Meeting of the Pennsylvania Entomological Society, held in Room 107, South Office Building, State Capitol, Harrisburg, Pennsylvania, Wednesday, January 12, 1949, at 1:30 P.M.

The following were elected members:

Dean Asquith
Harry Walker
Albert La Plante
William McGee
John Long
Kenneth Haines

The following officers were elected for the ensuing year:

Dr. M. W. Eddy	President
Dr. H. Menusan, Jr.	Vice President
Mr. E. J. Udine	Secretary

The members voted unanimously to apply for affiliation with the American Association of Economic Entomologists.

A history of the twenty-five years of the existence of the Society was prepared by G. B. Stichter and copies will be mailed to the members.

Dr. J. M. Corliss gave a brief history of the Gypsy moth in Pennsylvania and showed moving pictures of its control by airplane. Dr. Corliss stated that, as near as can be ascertained by exhaustive trapping and scouting, the Gypsy moth is eradicated in the treated area.

Dr. Bruce Gleissner gave an interesting talk on parathion, in which he discussed its toxic effects on animals.

The round table discussion of insects in Pennsylvania, in which all the members entered into, disclosed the following information of note:

Dr. Asquith discussed the peach lecanium flare-up, which during the past year caused considerable injury to peaches and applies. This lecanium was found on 16 annual weeds.

Mr. Gesell discussed an unsuccessful demonstration with parathion to control curculio of apple. Several apple varieties were injured.

Dr. Menusan discussed taste reactions of some of the newer insecticides and suggested that caution be used in their use.

Mr. Clarke described the results of using chlordane for the control of ants in bee hives without apparent injury to the bees.

The next meeting will be held during the next Pennsylvania Farm Show Week.

The meeting was adjourned at 5:30 P.M.

E. J. UDINE, *Secretary*

Rocky Mountain Conference

The twentieth Rocky Mountain Conference of Entomologists will be held in the mountains at Cameron Pass Camp about 85 miles west of Fort Collins, Colorado, August 16 to 20, 1949, inclusive. Arrangements will again be such that members of the families can enjoy an outing while the meetings are in session.

For detailed information write the Secretary, George M. List, Department of Entomology, Colorado A & M College, Fort Collins, Colorado.

Application of the Entomological Society of Pennsylvania for Affiliation

The Entomological Society of Pennsylvania, an organization founded in 1924 of persons living in Pennsylvania and engaged in the work of entomology or allied fields, do herewith apply for affiliation with the American Association of Economic Entomologists.

The objective of the Society is to serve as an annual get-together of Pennsylvania Entomologists at which time insect problems, new developments and taxonomy are discussed. There are no dues or fees.

The Society meets regularly once a year during the Pennsylvania Farm Show week in Harrisburg. This is usually the second week of January.

The present officers are as follows: President—Dr. M. W. Eddy, Dickinson College; Vice President—Dr. H. Menusan, Jr., Pa. State College; Secretary—Mr. E. J. Udine, Pa. State College.

The Society is free of debt and has been in continuous existence for twenty-six years.

Members of the Society are as follows:

Beck Koons	Geo. B. Sleesman
Norris Blackburn	H. A. Strohecker
H. W. Frings	G. B. Stichter
S. W. Frost	F. C. Campbell
E. H. Dusham	L. L. Pierce
E. L. Dills	Kenneth Haines
R. D. Casselberry	Harold Steiner
E. J. Anderson	A. J. Pruett
J. O. Pepper	W. H. Hanley
M. Menusan, Jr.	C. H. Hadley
W. W. Clarke, Jr.	M. W. Eddy
S. G. Gesell	Wm. H. McGee
F. J. Udine	Arthur Jeffrey
A. A. LaPlante, Jr.	Robert B. Troxel
James Cox	J. M. Corliss
C. A. Thomas	John Long
T. L. Guyton	H. G. Walker
A. B. Champlaine	Dean Asquith
E. M. Craighead	The Mellon Institute
W. C. Wheatfield	The Carnegie Museum
H. S. Kirk	Noel C. Farr
C. A. Kent	

New Officers of Texas Entomological Society

At the meeting in Waco, Texas, February 17 and 18, 1949, Cameron Siddall, Bryan, Texas, manager of the Southwestern Division of the Pennsylvania Salt Manufacturing Co., was elected president; H. G. Johnston, head of the Department of Entomology at Texas A & M was elected vice-president; and L. F. Curl of the Pink Bollworm Division, B.E.P.Q., San Antonio, was re-elected secretary-treasurer.

C. W. Collins

Mr. C. W. Collins, for almost forty years a member of the Bureau of Entomology, died on October 19 and was buried on October 21 at Morristown, New Jersey.

Dr. B. H. Wilford, of Mendham, New Jersey, represented the Bureau of Entomology and Plant Quarantine at the funeral.

A more adequate obituary notice will appear in a subsequent number of the JOURNAL.

BOOK REVIEWS

GALL MIDGES OF ECONOMIC IMPORTANCE, Volume 3, Gall Midges of Fruit by H. F. Barnes. 184 pp., 9 plates, Crosby Lockwood & Son, London. 15 shillings net.

Like the preceding two volumes entitled, "Gall Midges of Root and Vegetable Crops" and "Gall Midges of Fodder Crops," this compendium gives a thorough account of all the gall midges attacking fruits of all descriptions from all parts of the world. It is extremely well arranged and the fruits are listed alphabetically except that related fruits are grouped together and the gall midges attacking them are treated under the same heading. For example, almond, apricot, cherry, peach and plum are treated in the first grouping since several of the fruits are attacked by the same species. Under this heading the place attacked is divided into buds, leaves, flowers, fruit and stem. If the same midge should attack other fruits of other plants it is not treated in detail later in the work but reference is made to the preceding fruit which is attacked. It might be supposed that there might be some confusion concerning the alphabetical arrangement of the fruits listed throughout the work, but this is not the case because on page 15 and the following several pages, all the fruits are listed alphabetically and it is possible to follow this alphabetical arrangement and to turn at once to the fruit concerned.

The coverage of both fruits and insects belonging to the Cecidomiids attacking them is quite complete and most thorough and there is no doubt that anyone using this book will have no difficulty in discovering either the fruit or the pest or both concerned under any circumstances.

The book contains extremely fine illustrations of damage caused by the insect and also illustrations of the adult insects.

The author has made a most thorough survey of the literature dealing with all midges attacking fruits from all parts of the world and has done an extremely fine job of bringing together all that is known about them. Following the descriptions and type of damage caused by the pests there is a bibliography of the most important references dealing with each one. In addition there is a complete bibliography following the general text: this is followed by indexes of the midges and of the plants.

This book is one of the really important contributions to the knowledge of gall midges of the world and anyone interested in the recognition and control of these pests attacking fruit, must have this book in their library. It gives the latest methods of control and the latest methods of recognition of the pests. There is no doubt that it will be followed by other volumes dealing with gall midges attacking such crops as trees, miscellaneous crops, cereals and then a general miscellaneous discussion of midges atracking various plants of various sorts, including those that attack weeds. These, of course, are of economic importance inasmuch as they may be of value in controlling weeds and other plants that are not wanted.

INSECTS OF HAWAII. By Elwood C. Zimmerman. Vol. 4—*Homoptera: Auchenorhyncha.* Vol. 5—*Homoptera: Sternorhyncha.*

These are the last two volumes of Zimmerman's work on the "Insects of Hawaii." The closer the subject matter of this work comes to the reviewer's interest, the more interesting and useful it becomes.

Volume 4, which includes all the leaf hoppers of the Islands, is valuable as a long overdue summary of the 313 species of this group found in the Islands. It is of interest to note that only 16 are introduced forms, although these 16 include many of the most devastating economic insects the islands have ever known. The volume is as the others; beautifully illustrated and in this particular case, extremely well keyed. In addition there are, for the readers not too familiar with the taxonomic characters of each group, good detailed line drawings which are quite adequate for their purpose. Zimmerman has added significant data on the economic species. It would be very interesting indeed to know how many of these native species of leaf hoppers are capable of transmitting viruses, and how many native viruses there are in the forest from which most of them come. There is a choice field of investigation for someone here.

Volume 5, which includes the Psyllidae to the Diaspididae, appeals to this reviewer as being a magnificent job. The volume is particularly rich in determinative illustrations. The taxonomic detail is adequately presented and once more the keys are complete. Zimmerman has been particularly fortunate when writing this volume, to have the cooperation of artists who have contributed so significantly to its success, but in addition to this a great many of the species are shown from photographs as they appear in life. Anyone who has worked with mealybugs knows that this is an essential which many taxonomists, by virtue of necessity, have not been able to pay much attention to. But the photographs from life, taken in conjunction with the perfectly beautiful reproductions of Ferris and other illustrators, make this volume stand out as a really superior one. In addition, Zimmerman has also added considerable economic detail where this was available so that the volume is by no means a taxonomic treatise but a complete and well-rounded treatment of the insect groups covered.

The complete set of the five volumes consists of the following:

Volume 1. Introduction	$3.50
Volume 2. Apterygota to Thysanoptera	5.50
Volume 3. Heteroptera	4.50
Volume 4. Homoptera: Auchenorhyncha	4.50
Volume 5. Homoptera: Sternorhyncha	6.00

WALTER CARTER

THE FIG by Ira J. Condit. Foreword by Walter T. Swingle. Waltham, Mass., Chronica Botanica Co., New York City, Stechert-Hafner, Inc. 10¾×7 inches. xvi+222 pp., frontis., and 27 figs. $5.00.

One does not have to be a botanist, horticulturist or a fig grower to enjoy this authentic and interesting book by Dr. Condit, long an authority on subtropical fruits. The only work in English, of its kind, on the fig, it embraces in one volume all the essential facts about the fig and answers more questions about fruit than one can think of. It is not a manual of fig cultivation but an inclusive account in all other respects.

Beginning with the fig in song and story one is led through its history and distribution to its gen-

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eral and specific botanical characteristics, then to the process of caprification and to fig breeding. There are chapters on fruit characters and fig varieties. The fig districts of the world are treated and also the effects of climate. There is a chapter on propagation, and one on culture which includes altitude, soils, planting, pruning, tillage, etc. These are followed by accounts of the fresh and dried fig crops, including picking, packing, shipping, drying, bleaching, etc., of fig products, of the chemistry and food value of figs, of marketing, and finally, of insect and plant disease enemies of the tree and fruit. An extensive bibliography of approximately 675 references ends the volume. Dr. Condit's treatment in the main is historical, but it is history brought up-to-date. It is interesting to know that although caprification was known to Aristotle and his pupil Theophrastis as far back as 340 B.C., the true nature of the process was not clarified until the successful introduction of the blastophaga into California in 1899 and until later studies were made.—H.B.W.

Migrations and Activities of Entomologists

By HARRY B. WEISS, *Associate Editor*

RESIGNATIONS, APPOINTMENTS AND NEWS

Mr. Rudolph Strong, who has a B.S. and M.S. from Mississippi State College and who taught Zoology and Entomology at that college from 1946 to 1948, has been appointed Extension Entomologist in Louisiana with headquarters at Louisiana State University, University Station, Baton Rouge 3, Louisiana. The effective date of this appointment was January 28, 1949.

Mr. Chas. A King, Jr., Extension Entomologist in Texas, resigned January 31, 1949 to accept a position as Director of the Educational Division in Texas for the Geigy Company and will make his headquarters at Waco, Texas.

Mr. Allen C. Gunter, who has a B.S. degree from Commerce State Teachers College in Texas and an M.S. degree from A. and M. College of Texas and who has been a member of the Entomology Staff of A. and M. College of Texas since 1946, accepted the position of extension entomologist in Texas to fill the vacancy created by the resignation of Mr. King. The effective date of his appointment was February 1, 1949 and his headquarters will be A. and M. College of Texas, College Station, Texas.

Mr. James A. Deer, who has a B.S. degree and an M.S. degree from A. and M. College of Texas and who has been graduate assistant in the Department of Entomology during the past year, has accepted the position of Assistant Extension Entomologist in Texas to fill the vacancy created by the resignation of Mr. Paul Gregg who resigned some time ago to accept a commercial position. The effective date of Mr. Deer's appointment was February 1, 1949, and he too will be located at A. and M. College of Texas, College Station, Texas.

William P. Hayes has been appointed to be head of the Department of Entomology of the University of Illinois. For the past two years he has served as acting head of the department as well as chairman of the Biological Division of the University.

Dr. C. A. Sooter, Extension Entomologist in Nebraska, resigned January 1, 1949, to accept a position with the U. S. Health Service in Kansas City, Missouri.

C. W. Kearns in charge of the insecticide and toxicological work at the University of Illinois has been asked by the American Medical Association to serve on the Committee on Industrial Hazards.

Mr. B. Thomas Snipes has changed his business association to United States Industrial Chemicals, Inc., and has established new headquarters in Denver, Colorado, Mr. Snipes was formerly located in Powell, Wyoming, where he represented the Insecticide division of Dodge & Olcott Inc. Mr. Snipes has established a new home in Denver where he, along with Mrs. Powell, now resides.

Mr. James T. Conner, Jr., Extension Entomologist, North Carolina State College, has resigned to accept a position with the Taylor Chemical Company, Aberdeen, N. C.

Dr. Henry K. Townes, Jr., Entomologist with the U. S. Department of Agriculture, has accepted a position as Associate Professor of Entomological Research at North Carolina State College to do research work on investigations of tobacco insects.

Dr. Z. P. Metcalf, Head of the Department of Zoology and Entomology at the North Carolina State College was elected president of the Ecological Society of America at their last annual meeting.

Herman F. Menke, a graduate of the University of California has been appointed to a research position in apiculture at the Washington Agricultural Experiment Station, Pullman, Washington. Mr. Menke will devote most of his time to pollination problems and to bee poisoning.

Philip H. Marvin has joined the Haddonfield, N. J., research staff of the California Spray-Chemical Corporation, and will work with Dr. T. W. Reed.

G. S. Fraenkel of the Department of Entomology of the University of Illinois has been invited to participate in the Gordon Research Conferences sponsored by the AAAS which are to be held at Colby Junior College, New London, Connecticut, from June 20 to September 20. He will discuss the subject "Insects in Vitamin Research with Special Reference to New B-Factors" before the Vitamins and Metabolism Section on August 10.

Leslie G. Smith has become a member of the field research staff of the California Spray-Chemical Corporation at Richmond, California. Mr. Smith joined Calspray direct from the University of California.

Mr. E. H. Coe, formerly with the Sherwin Williams Company on the Pacific Coast, has joined the staff of Julius Hyman & Company, of Denver, Colorado, and will serve as Entomologist and technical representative of this Company on the Coast. Mr. Coe's headquarters will be 9 Main St., San Francisco.

Mr. Clyde R. Weaver has been appointed as Assistant Entomologist at the Ohio Agricultural Experiment Station effective April 1, announces L. L. Rummell, Director.

For the past three summers, Mr. Weaver has assisted in insect control investigations as a graduate student. During this time he has been author of several papers dealing with parasitization of the Oriental fruit moth. His work at the Ohio Station will deal with insect problems involved in the production of forage crops including both legumes and grasses.

Mr. Weaver, a native of Akron, holds degrees from the University of Akron and The Ohio State University.

Dr. A. A. LaPlante who has been working with the extension entomologists at State College, Pennsylvania, for the past two years is leaving at the end of April to go to Cornell for further work. A new man will eventually be placed on the extension staff here.

Dr. John A. Comstock, the well-known lepidopterist and chief curator of natural science at the Los Angeles County Museum for 20 years, retired on October 1, 1948.

Dr. Bernard D. Burks of the Taxonomic Division of the Illinois State Natural History Survey has resigned his position to accept a similar one with the Division of Insect Identification, U. S. National Museum.

On May 3 Dr. Karl von Frisch of the University of Graz lectured before the members of the Biological Division of the University of Illinois on the subject "The Language of Bees."

DOCTOR FLOYD F. SMITH HONORED.—The Society of American Florists and Ornamental Horticulturists through the Foundation for Floriculture has granted Dr. Floyd F. Smith its First Annual Award for the year's most outstanding accomplishment in floriculture research in recognition of his work on aerosols for the control of greenhouse pests.

The presentation was made on August 2 at the 64th Annual Convention of the Society at Chicago, Illinois.

Dr. G. S. Fraenkel of the Department of Entomology, University of Illinois, attended the Biochemical Meetings held in Detroit in April where he presented a paper on the subject of insect nutrition.

NOTICE

"A History of Entomology in Relation to World War II" is now being prepared. Suitable photographs and reprints of published articles dealing with any phase of entomology in connection with the war effort are urgently needed to complete this project. It is requested that persons having such material send it immediately to Emory C. Cushing, General Editor, Route 1, Box 38, Stockdale, Texas. Photographs should be accompanied by appropriate explanation and statement of source.

Dr. H. G. Baer of the University of Neuchatel, Switzerland, is a visiting professor on the zoology staff of the University of Illinois this semester. Recently he gave two lectures before the entomological club on the subject of parasitism of insects.

INFORMALITY

Dr. L. O. Howard wrote in Insect Life, 1894 (vol. 7, No. 2) that the A.A.E.E., when it was founded in 1889 adopted the name "The Association of Official Economic Entomologists." A year later the word "official" was dropped. The organization meeting at Toronto, Canada on August 30, 1889 was held on a wooded knoll at Scarborough Heights overlooking Lake Erie. Professor Cook presided astride a fallen log. Dr. John B. Smith took the minutes, while perched on top of a tall stump. Others present reclined upon the ground or sat cross-legged upon convenient ant hills(?).

ANDREW JACKSON'S BEETLES AND BUTTERFLIES

In his book on "The Life of North American Insects, 1854," the author Benedict Jaeger, states that "the late General Andrew Jackson, president of the United States, presented me in 1834 with two large boxes of splendid beetles and butterflies, but, much to my regret, on opening them I found the largest and handsomest specimens destroyed by dermestids."

EARLY INSECT DESCRIPTIONS IN AMERICA

One of the earliest insect descriptions published in America appeared in 1798 in the Medical Repository, which flourished from 1797 to 1824 under the senior editorship of Samuel L. Mitchill, and was entitled "An Account of a Species of Cantharis found in Bucks County, Pennsylvania" by Isaac Chapman, a physician.

NEWSPAPER ENTOMOLOGY IN 1806

Newspapers in 1806, because of a dearth of foreign and domestic news, enlivened their pages with an account of a "worm" that was spreading terror through New York and neighboring states. This "worm" which infested Lombard poplars, was credited with causing the deaths of dozens of men, women and children and even cats, dogs and horses had fallen victims to its venom. An anonymous author in the 1807 "Medical Repository" found that the "worm" was a caterpillar which he bred through to the adult stage and identified as a species of Phalaena.

PUBLICATION DIFFICULTIES

Nathaniel Dwight, physician and one of the brothers of Timothy Dwight, one time president of Yale College wrote "An Account of the American Cantharis or Meloe Americae" in September, 1800 and did not get it published until 1810 when it appeared in the Memoirs of the Connecticut Academy of Arts and Science. Nothing is on record to account for the delay.

JOINT WORM CONVENTION OF 1854

According to the Southern Planter (1854, p. 246), a convention of farmers was held at Warrenton,

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Virginia for the purpose of considering the ravages of the joint worms, which were serious and extensive enough for farmers to consider the abandonment of wheat culture. After due consideration a set of resolutions were adopted calling for the early sowing of the hardiest varieties, the liberal use of fertilizer, the burning of stubble, etc., and the promise of all present to exert themselves in having such a plan put into operation in all their neighborhoods.

Yellow Fever

In 1848 Dr. Josiah Nott of Mobile, Alabama, published an article on the cause of yellow fever and gave reasons for supposing its specific cause to exist in some form of insect life. His paper was a denial of the "malarial" origin of hot climate fevers, but his use of the term "insect" was such as to mean a low form of life. If he had any ideas relative to insects and yellow fever, his expression of them was quite vague.

Entomological Personnel in 1888

In the Division of Entomology, U.S.D.A., Entomologist; C. V. Riley; Office Staff: L. O. Howard, First Assistant; E. A. Schwarz, Th. Pergande, Tyler Townsend, W. B. Alwood, Assistants, Agents: Samuel Henshaw, Boston, Mass.; F. M. Webster, Lafayette, Ind.; Herbert Osborn, Ames, Iowa; N. W. McLain, Hinsdale, Ill.; Mary E. Murtfeldt, Kirkwood, Mo.; Lawrence Bruner, West Point, Neb.; D. W. Coquillett, Los Angeles, Cal.; Albert Koebele, Alameda, Cal. In the Department of Insects, U. S. National Museum, Honorary Curator, C. V. Riley; Assistant Curator, John B. Smith.

Rafinesque's Review of Say's "American Entomology"

When Say's "American Entomology" appeared in 1817, C. S. Rafinesque wrote a review of it for the American Monthly Magazine and Critical Review of December, 1817, in which, while recognizing Say's ability as an entomologist, he deplored the style of publication. He said—"it is true that we are offered an elegant specimen of typography but the price of it is two dollars. For that sum we have forty pages (of which twelve are quite blank) printed on beautiful paper, and six fine coloured plates, containing only eight species (whereof five are new) of insects, while they might have included sixty. Therefore at this rate, as there are at least eight thousand species of insects in North America, the sum of two thousand dollars will be requisite in order to admire the insects on this new plan, while on the plan of Linneus, &c. ten dollars might be quite sufficient."

Early Entomological Prizes

In 1795 William Dandridge Peck won a prize of $50.00 for his paper entitled "The Description and History of the Cankerworm" which was printed in the Massachusetts Magazine. In 1799 he won another prize of $50.00 together with a gold medal for his essay on the "Natural History of the Slug Worm." This was published in the Papers of the Massachusetts Society for Promoting Agriculture, which society made the awards.

At the beginning of the nineteenth century the American Philosophical Society offered a prize of $60.00 for the best method of preventing the premature decay of peach trees. Two papers of equal merit were selected for the award and the prize money was divided equally between John Ellis of New Jersey and Thomas Coulter of Pennsylvania. Both papers appeared in the 1802 volume of the Transactions of the Society. The paper by Mr. Ellis dealt with the peach tree borer and that of Mr. Coulter, with cultural methods for peach trees.

Dr. A. D. Imms Dies

Dr. A. D. Imms, the well-known British entomologist, died on April 3, 1949 at his home near Sidmouth, Devon, England. Dr. Imms was 68 years old and was a member of the faculty of Cambridge University from 1931 to the time of his retirement in 1946. Previous to that time he was on the staff of the University of Manchester from 1913 to 1931. He began his career in India as Forest Zoologist and a member of the faculty of Allahabad University. Dr. Imms was best known in this country as the author of a textbook in general entomology and other publications.

Army Reserve Commissions for Entomologists

Reserve commissions in the Army of the United States are now available to qualified entomologists who meet the requirements of age, education, experience and physical condition. The commissions range from those of First Lieutenant up to and including full Colonel, depending upon the qualifications and experience the entomologist possesses in his specified field. Applicants must be at least twenty-one (21) years of age for appointment in the Reserve Corps, and applications will be considered from individuals up to fifty-five (55) years. All must be citizens of the United States. No previous military experience is required.

For appointment in the grade of First Lieutenant for service as Medical Allied Sciences Specialists in the allied science section of the Medical Service Corps Reserve, applicants must meet one of the following three requirements:

1. Possess a doctor's degree from a school or college acceptable to The Surgeon General in any of the medical allied sciences listed below, or in other related sciences for which there is a demonstrated need in the Medical Department.

2. Possess a master's degree from a school or college acceptable to The Surgeon General, and have a minimum of two years of professional experience in any of the medical allied sciences listed below, or in other related sciences for which there is a demonstrated need in the Medical Department.

3. Possess a bachelor's degree from a school or college acceptable to The Surgeon General and have a minimum of three years of professional experience in any of the medical allied sciences listed below, or in other related sciences for which there is a demonstrated need in the Medical Department.

Bacteriology	Nutrition
Biochemistry	Toxicology
Parasitology	Industrial Hygiene
Serology	Industrial Hygiene Engineering
Entomology	

For appointment in the grades of Captain through Colonel, applicants must have met any one of the requirements for First Lieutenant as set forth above, and in addition have had further experience in the medical allied sciences as follows: for Captain, four years; for Major nine years; for Lieutenant Colonel, fourteen years; and for Colonel, nineteen years.

Applicants who possess bachelor's degrees in any of the nine above mentioned fields but who lack the specified professional experience to attain eligibility, may qualify for a commission in the field of pharmacy and medical supply and administration specialist.

Full details of the program for commissioning of civilian entomologists are provided in Department of the Army Circular No. 210, dated 14 July 1948. Application forms and Circular No. 210 may be obtained from local Reserve Unit Headquarters or from Organized Reserve Unit Instructors, or by writing to Army Headquarters at New York, Baltimore, Atlanta, Chicago, Houston or San Francisco. Inquiries and requests for application forms and the circular may also be addressed to The Adjutant General, Department of the Army, Washington 25, D. C.

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